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THE ELECTRIC OPERATION OF STEAM RAILWAYS

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THE possibility of operating all classes of steam railway service by electricity has been demonstrated beyond question. Heavier trains may be hauled at higher speeds and with greater comfort to passengers, and electric locomotives may be built which surpass in power any steam locomotive which may be constructed. Two of the most important railway systems entering New York city are now operated entirely by electricity for distances between twenty and thirty miles from Grand Central Station. The Pennsylvania Railroad Company has recently closed contracts to the extent of $5,000,000 for the electric operation of its tracks between Newark, N. J., through the Hudson and East River tunnels, to Jamaica, L. I., where it will join the tracks of the Long Island Railroad, which for some time has been operated electrically.

The total steam railway mileage in this country aggregates about 220,000 miles of line but notwithstanding the important projects mentioned above, and others of less note, it remains a fact that only about 1,000 miles of railroad, formerly operated by steam, have been transformed to the use of electricity as motive power. The question then arises as to what conditions have started the present development and as to whether this beginning will extend itself in general degree to the large trunk line systems of the country. It is not sufficient for the engineer of to-day to demonstrate the physical possibilities of a project, but he must go further, and justify it on the grounds of business advisability and economy. If, then, it be asked why have steam railroads begun to substitute electricity as motive power, the answer is to be found in two broad reasons. The first of these is, that in some in-

stances the use of electricity is the only possible way of handling the traffic. The second reason is the invariable one, in this commercial age, for all engineering enterprise—that it pays.

The development of the engineering methods by which the electrical operation of railways has been made possible is largely due to the first of the reasons mentioned above. Beginning with the electrification of the Mt. Royal Tunnel of the B. & O. Railroad, in 1896, there have been an increasing number of tunnel and terminal projects which have made use of the possibilities of electric operation in the way of increased traffic and freedom from smoke and gases of combustion. One conspicuous instance, the Grand Central Terminal in New York city, illustrates the typical limitations of tunnels and terminals which have rendered electric operation necessary. In 1903, an act of the New York Legislature was passed providing for the operation before July 1, 1908, of all trains into Grand Central Station by some form of motive power not involving the combustion of fuel in the motive units. This action was aimed directly at the elimination of smoke and gases in the tunnels leading to the terminal. The results of the adoption of electricity have in this respect entirely justified expectations. Passengers may now occupy observation platforms in passing through these tunnels which were formerly notorious for their danger and discomfort.

There was, however, an additional reason why it was necessary to adopt a motive power other than steam in the New York terminals. Traffic into the Grand Central Station is limited by the number of tracks in the tunnels. The minimum three-minute headway between trains operated by steam fixed the maximum traffic at forty trains per hour each way. The capacity of the terminal with this limitation of service was taxed to its utmost and some relief for the increasing traffic was imperative. Owing to the improved conditions of electric operation, trains may be run on a two-minute headway or less, thus increasing the station capacity by more than fifty per cent. The conditions in the New York tunnels are typical and other conspicuous instances of similar installations are those of the B. & O., at Baltimore, the St. Clair tunnel of the Grand Trunk Railway and a three-mile tunnel on grade on the Great Northern Railway. The Illinois Central Railroad is about to electrify 325 miles of track, comprising the approaches to its Chicago terminals.

The elevated lines of New York city are an additional instance of the necessity of adopting some other system than steam in order to increase the capacity for traffic. The continued growth of the population of New York city has far surpassed that of the traffic facilities for transportation within the city. As measures for relief the elevated and surface lines were equipped with electricity and in addition the subway system was constructed. Within three years following the adoption

of electricity, the capacity of the elevated lines in car-miles per day was increased 33⅓ per cent. and this in spite of the facts that the subway system had inaugurated during this time a service furnishing over 75 per cent. that of the steam elevated and that the surface lines showed little or no decrease. During the two years ending 1906 the increase in passengers on all the lines of New York city numbered more than 114,000,000, which is about 75 per cent. of the ultimate capacity of the subway system. In order to handle this continuously increasing demand it has now become necessary to consider the construction of additional subways.

Returning to the second of the reasons given for changing to electricity, the general statement that it will pay to electrify a steam railroad may not be made without important qualifications. It is admittedly true for the majority of steam roads of any considerable size and density of traffic that the operating expense would be substantially reduced by electric operation. Figures showing that this saving, together with the returns from increased business, is sufficient to offset the interest charges on the necessary capital are still few. Such figures have, nevertheless, been given for existing roads on which the transfer to electricity has been made. On the other hand, on railroads operating light trains and comparatively infrequent traffic, it is at once evident that there would be little if any saving in operating expense in changing the motive power. Much of the economy possible under electric operation results from the combination of all the locomotive boilers and engines into a central power plant. It is obvious that when the number of such locomotives is small that the cost of the power plant and the motor equipments may far outweigh the economies obtained. There is, however, an intermediate class of road, many instances of which have been equipped electrically, in which the saving in operating expense, together with the usual increase of business following the electric installation, are looked to for a reasonable return on the capital invested. The enormous amount of capital represented by the steam equipments of existing railroads, which can not be applied to the new equipment, is the most serious obstacle to the general adoption of electricity as motive power. It will only pay to electrify in those cases where the economies in operation and the increase in business will outweigh the charges on the new capital necessary.

The public will invariably drift to an electric rather than a steam route between given points. Moreover, when a steam road is paralleled by electric service, not only does the latter take the bulk of the traffic, but the traffic itself increases in volume. Further, when a sparsely settled section is penetrated by an electric road, population and consequent business follow promptly. These facts are now matters of common observation. One extreme example will indicate the lengths to

which these facts may go. A steam road in the middle west was paralleled by an electric line; the latter took away over fifty per cent. of the steam traffic and increased the total traffic fifteen times the original amount within seven years. If we look for the reasons for such advantages in absorbing and promoting traffic we realize that electric travel is faster, more frequent and more comfortable. It provides freedom from smoke, better ventilation, easy regulation of light and heat and in fact travel in many instances is actually a pleasure.

While the public is appealed to as cited above, the operating and transportation departments of the railroad are equally appealed to by the methods afforded under electric operation for handling the resulting increase in business. Present day steam service may be divided into three broad classes: (1) Suburban and terminal; (2) long haul passenger and express and (3) freight traffic. The advantages of electricity as motive power in all three of these classes of service are found in the possibilities of obtaining more mileage and hauling capacity from the equipment, the operation of more trains on the line at one time and better operating conditions and consequent reliability.

Figures have already been given showing the increased train capacity of the several electric installations in and about New York city and many other similar instances might be cited. These results are largely due to the fact that an electric locomotive or train operates at a higher schedule speed than is possible under steam. The elapsed time of a suburban train between stops depends principally on the rapidity with which it attains its maximum speed. The rate at which it reaches this speed, that is, the acceleration, depends on the value of the pull exerted by the motive power. During the period of starting the greatest draw-bar pull is required, since during this time the inertia of the mass of the train must be overcome. After reaching a maximum speed the only forces to be overcome are those of frictional resistance of the track and the air. In a steam locomotive the greatest draw-bar pull being required at starting, steam is admitted to the cylinders throughout the full length of the stroke. The demand on the boiler per revolution is, therefore, greatest at this time. No locomotive can, on the average, exert a greater pull than 25 per cent. of the weight carried by its own driving wheels, for beyond this figure the wheels will slip on the track. The boiler capacity, therefore, is designed to give no more steam than that demanded by this value of the pull at starting. A steam train, therefore, does not utilize the weight of its own cars as a means of increasing its grip on the rails. In a multiple unit electric train, motors are placed on each car, thus utilizing the weight of the entire train for frictional adhesion to the rail. By electric control of the motor switches all the motors may be operated simultaneously by one man at the head of the train. By this

system the draw-bar pull per ton of train may be increased from 2.5 to 4.5 times that for steam and the rate of acceleration is only limited by the comfort of the passengers. As a direct result of this the schedule speed is increased, the headway between trains is reduced and more trains may be operated on the line. By the use of electric locomotives in terminals for switching service great economies are effected. Since the electric locomotive operates in either direction and takes its entire power supply from the trolley or third rail, much useless mileage of locomotives in going to and from the turn-table, the water-tank and the coal-chute is avoided. The New York Central has already reported as a result of tests a net saving of 21 per cent. on the cost of switching service and 16 per cent. in the ton mileage of switching locomotives.

For long-haul passenger and express service rapid acceleration is not so important, but the maximum speed becomes the determining factor in a fast schedule. For any type of motive power the draw-bar pull is greatest at starting and falls to lower and lower values as maximum speed is approached. Consequently, for this class of service, large initial effort is not so important as large effort at high speed. In this respect the electric motor has a great advantage over the steam engine. Since the boiler of the steam locomotive is proportioned to the maximum demand which it can generate at starting, corresponding to the grip which it has on the rails, at higher speeds the steam must be cut off from the cylinders at a less and less fraction of full stroke, for otherwise the boiler can not supply steam fast enough and still maintain its pressure; thus the total tractive effort, which depends on the proportion of a revolution during which steam is admitted to the cylinders, is reduced as the speed increases. While the tractive effort of the electric motor also decreases somewhat with the speed it does not do so nearly as rapidly as that of the steam locomotive. As a consequence, a given weight of train can be handled faster by electricity than by steam or a heavier train may be hauled at a given maximum speed. Again, the safe limits of speed are much higher in electric operation. The rotative effort is uniform in a motor, while that of a locomotive is intermittent and accomplished through the medium of heavy reciprocating parts. The moving mass of these parts as the speed increases tends to lift the locomotive from the track and pounds the rails with a blow which in many instances has been sufficient to cause derailments. The limiting speed of steam trains is about 80 or 90 miles per hour, while speeds of 130 miles per hour have been reached in tests on electric trains.

The advantages of electricity for freight traffic are most apparent on long single track lines with heavy grades and mixed traffic. The length of the freight train of to-day is limited by the draw-bar pull of the locomotive which is in turn dependent on the locomotive weight,

and by the schedule speed. Speaking generally, longer trains and hence fewer trains on the line at one time, are to be had only at great sacrifice of speed. The longest freight trains weigh from 2,000 to 3,000 tons and are only operable on level track. On reaching mountain grades, such trains have to be broken into two or three parts, which, therefore, on single-track roads increase the number of passing points and subsequent delays, thus rapidly shortening the headway between trains and filling the line to its capacity. Schedule speeds on such grades now average about ten miles per hour. The operation of two or more locomotives in a train is not satisfactory, owing to the impossibility of securing simultaneous cooperation of the several motive units. As already stated the tractive effort at high speeds is much greater for the motor than for the steam locomotive; hence, in the case of electric operation, the limiting weight of the train on grade is higher, also the schedule speed may be largely increased by the use of double or triple headers. This method of operation is perfectly possible under electricity by the system of multiple control, already mentioned, and the length of a train is limited only by the strength of the draft gear. This limit would disappear if all freight cars could be equipped with a simple standard cable, enabling the placing of an electric locomotive in the middle or at the end of a train. This cable would be necessary to secure the simultaneous operation of the several locomotives.

A few comparative figures bearing out the above facts of the possible methods of increasing railway business are not without interest. A typical western freight locomotive, weighing with its tender 165 tons, can develop continuousiy a draw-bar pull of 25,600 pounds, up to a speed of 15 miles per hour. An electric locomotive, weighing 100 tons, can develop this value of pull, up to a speed of 37 miles per hour. Another similar type of electric locomotive gives 56,800 pounds, up to 23 miles per hour, and still another 8-motor type can develop 113,600 pounds draw-bar pull up to a speed of 23 miles per hour.

A late type of Mallet compound locomotive, weighing 300 tons, can develop continuously 2,180 horse power at its driving wheels. A New York Central electric locomotive can do the same and weighs only one third as much. The cost of each locomotive is about the same. It may be noted that 200 ton-miles are saved in every locomotive mile if the electric locomotive is used instead of the steam locomotive. At 40 cents per locomotive mile and 100 miles per day the saving is $40 per day or about $15,000 per year. The saving on this account alone would in two years pay for the electric locomotive. Another type of Mallet locomotive, weighing with its tender 250 tons, can haul a train weighing 330 tons up a 2.2 per cent. grade at 15 miles per hour. A 100-ton electric locomotive can haul a train of 800 tons under the same conditions. The total train weights are thus 580 and 900 tons and the

electric locomotive weighs 100 tons less than the steam locomotive, resulting in the consequent saving in the ton mileage of dead weight.

The operating conditions and the reliability of service are improved in all classes of traffic by the substitution of electricity. The construction of the electric locomotive is far simpler. The steam locomotive comprises fire box, boiler, steam engine and facilities for handling coal and water. The electric locomotive, on the contrary, consists only of the electric substitute for the engine and this substitute has no reciprocating parts. There is consequently less wear and tear and less likelihood of derailment and broken rail. The fire box and boiler are absent as sources of danger in a collision, as are also apparatus for steam or fire heating and oil or gas lighting. Signals are clearer in the absence of smoke and automatic signals are possible, though as yet they are little used. The control of power to trains in sections or blocks is also possible. The number of car miles per train-minute of delay has been nearly doubled on the elevated lines of New York since the electrical operation was inaugurated. Less time is required for clearing and despatching trains, water and coal stops are obviated and less attention is required for light and heat. The electric locomotive is always ready, requiring no time for firing.

As against these several advantages in operating conditions and reliability, there are several disadvantages. The supply of power to all trains from one power house is objectionable from the standpoint that an accident at the power house may stop all trains. Whatever may be said of the steam locomotive in its comparison with the electric motor, the locomotive is self-contained. This danger under electrical operation is minimized by a thorough subdivision of all the power house apparatus. This method of subdivision, however, is not so readily possible in the transmission and conducting systems leading power to the trains and accidents to this portion of the equipment constitute one of the most serious menaces to the continuous operation of an electric railroad. The presence of the third rail or trolley and the transmission line throughout the right of way is in itself a certain source of danger. In a collision the danger of a fire from a third rail in some measure offsets the similar danger from a locomotive fire box. The danger from this source, however, has been overestimated, and the danger of shock from a high voltage trolley is practically eliminated by the modern methods of suspension. These methods consist in supplementing the actual trolley conductor with one or more steel cables for increasing the tensile strength of the overhead construction. The thorough grounding or connecting to the rail of all the supports of the trolley wire ensures that even in the unlikely instance of the breaking of the overhead construction the wire will have no voltage when it reaches the ground. So reliable has this method of suspension come

to be regarded that it is now often used for crossings of telegraph, telephone and transmission wires in place of the usual cradle or network of wires stretched between the two lines. The values of voltage now advocated for railway and transmission work have caused considerable criticism and opposition. This is probably due in large measure to the long standing figure of 600 volts for trolley service; this figure, however, is fixed by the character of the direct current motor and not by any consideration of possible danger from shock. A further source of disturbance by electrical operation is the interference by electrostatic and electromagnetic induction between the transmission conductors and the telegraph and telephone lines in the vicinity. Methods have been developed, however, and are at present in use by which such disturbances are prevented at slight cost.

A decrease in the operating expenses has already been stated as one of the means by which electric operation may be made to pay. The operating expenses of an average steam railroad may be roughly divided as follows: Maintenance of way 21 per cent., maintenance of equipment 19 per cent., conducting transportation 56 per cent., general expenses 4 per cent. Considering these items under electric operation the greatest saving is effected in the item of conducting transportation, which includes the cost of coal. The steam locomotive consists of a boiler and engine. For obvious reasons neither is as efficient as the same apparatus of a stationary type. The same amount of coal in a locomotive boiler will evaporate only about two thirds as much water as in a stationary boiler. The average steam consumption of a good locomotive engine is about 30 pounds of steam per horse power hour developed; turbo-generators are now guaranteed for a consumption of only 15 pounds of steam per electrical horse power at the switchboard. As offsetting these marked advantages it is necessary to consider the electrical losses in the transmission system and in the motor equipments. Speaking roughly, 75 per cent. of the electrical energy supplied by the switchboard is available at the wheels of an electric train for tractive effort. These figures indicate that an electric locomotive requires less than one half the amount of coal used by the steam locomotive giving the same horse power output. Further than this, it has been estimated that for every hour that a locomotive is standing idle, with steam up, 400 pounds of coal are burned. The excess of useless mileage and the excess ton mileage owing to the greater weight of the steam locomotive have already been noted, and are also causes for excess coal consumption. As opposed to these, there is the light load coal consumption of the power station. The final value of the balance in coal saving will depend on the proportion of time in which the power station operates to its full capacity. Based on careful comparative tests of steam and electric locomotives the engineers of one of the large

installations already mentioned have announced that the electrical operation of the former steam service is being handled with the consumption of only 60 per cent. of the amount of coal, resulting in a saving of nearly $350,000 per year. Figures have been published showing that the Manhattan Railway under steam operation secured about 1.5 ton miles to a pound of coal; under electric operation this figure has increased to 3.85. These and other careful estimates indicate that in the general electrification of through railway lines a saving of 50 per cent. in coal consumption may be effected. It is to be noted, however, that the cost of fuel alone is only about 12 per cent. of the total cost of operation; therefore, a saving in this respect would be only 6 per cent. of the total operating expense. In the kindred items of firemen, roundhouse men and other expense peculiar to the steam locomotive a further saving of about 5 per cent. is possible. It is interesting in this connection to consider the effect of this fuel saving on the total coal supply of the country. The fuel consumption of all the locomotives in this country in 1905 was about 52,000,000 tons, which was about one eighth of the total coal production of that year. The total coal consumption, therefore, would be reduced by about 7 per cent. if all the railways in the country were electrified. This does not appear to be a very important reason why railways should electrify; but with trans-Atlantic liners burning 5,000 tons of coal per voyage and the end of the coal supply of the state of Ohio in sight within 25 years, any influence tending to check coal consumption must soon assume importance.

The repairs to steam locomotives amount to about 8 per cent. of the total operating expense. The repairs to an electric locomotive amount to far less. The greater simplicity of the electric locomotive has already been noted. There are now available plentiful data based on experience indicating that the above figure of 8 per cent. may be reduced to the neighborhood of 2 per cent. An additional saving in the maintenance of track and other less striking items offsets the repairs to track bonding and overhead construction and leaves an additional saving in favor of electric operation of about 3 per cent. The aggregate of the above economies in operating expense amounts to 20 per cent., which should be readily available by any of the large railway systems in the transformation to the electric method of operation.

Considering further the several pioneer installations of electric service, we find that they differ materially in their characteristics and there are several so-called systems at present available. The early development of the electric railway for operation in cities was entirely dependent on the use of the direct current motor as the only motor available. This motor had been developed in spite of the fact that the earliest electromagnetic generators were of the alternating current

type. The value of alternating currents was not appreciated, however, as the principles of transformation and their value for transmission were not understood. The high degree of perfection to which the direct-current motor has been developed naturally led to its use for railways as city lines were extended, and this tendency has resulted in the enormous mileage of suburban and interurban electric railways. This tendency was aided by the development of the rotary converter which permitted the transmission of power by alternating currents and its conversion to direct current for supplying the trains. The direct current motor operates at about 600 volts and thus fixes the value of the voltage on the trolley or third rail. The voltage being fixed, the total energy at a car is proportional to the current. Thus, for light cars and infrequent traffic, the loss in the trolley and feed wires, due to the passage of current delivering energy to the car, is sufficiently small to allow operation at comparatively long distances from the point of generation. With increasing size of cars or trains the points of supply must be brought nearer together and be made of greater capacity. In the case of the New York Central installation, the average distance between such stations is four miles. Each of these sub-stations contains transformers for reducing the voltage from the transmission line and rotary converters for changing the alternating to direct current. The amount of current taken by a train on this system may go to very large values and this necessitates large trolley and feeding conductors when the traffic increases in volume. Under this system the feeding conductor may be either trolley or third rail and the collecting device, the trolley wheel or third rail shoe. The latter must be used when the currents are of large value.

With increasing length of line the cost of sub-stations and feeders in the direct current system becomes prohibitive. This has lead to the development of alternating current systems, in which the energy is generated, transmitted and delivered to the car at voltages as high as 15,000, with consequent reduction in values of the necessary current. Theoretically, the reduction in the size of conductors necessary to carry the current is inversely proportional to the square of the voltage. While certain characteristics of the alternating current system reduce this theoretical value quite materially, the gain in this respect is nevertheless enormous, and the distance between feeding points increases to between thirty and fifty miles, depending on the density of the traffic. The trolley wire alone is often the only feeding conductor required. Further, the apparatus in the sub-stations in these systems comprises stationary transformers only which require no attendance. Two conspicuous alternating current systems for railway operation have been developed. The single phase system, which has been almost the only alternating current system used in this country, and the three-phase system, which has met with some favor in Europe.

The single-phase motor has the same characteristics and operates exactly as the direct current motor and may in fact be operated by direct current—a fact which constitutes one of its greatest advantages. It is, however, heavier for the same output and since it, too, operates at low voltage, a stationary transformer is required on the car or locomotive to reduce the high trolley voltage to the value required. This necessitates a heavier and more expensive motor equipment than the direct current system and acts as an offset to the saving effected in feeding conductors and sub-stations. In this system the feeding conductor is the overhead trolley with catenary suspension and the collecting device is the sliding trolley or pantagraph which is necessary for very high speed and permissible by reason of the low values of current required.

The three-phase system owes its principal value to the fact that the speed variation of the motor is very small throughout its full range of tractive effort. As already stated, the tractive effort of the direct-current and single-phase motors falls off with increasing speed, though not so rapidly as that of the steam locomotive. Owing to this advantage, the three-phase locomotive can maintain its high speed independently of the grade. It operates without transformers on the car with trolley voltages up to 5,000 and in coasting it returns power to the line automatically, its motors acting as generators. It is, however, heavy per unit of output and the system requires two trolley wires and is not adapted to operation on the direct-current installations to be found in many terminals. It has been adopted for one installation in this country in which it is desired to increase the schedule speed on a long mountain division.

In this country the best engineering opinion seems to have united in thinking that the single-phase system is the one best adapted for future application to steam railways. This system is as yet only four years old, yet there are at present over 1,000 miles of railways in the United States operating under it and in this aggregate there are at least five railroads formerly operated by steam. The system has proved most successful in operation, although the first six months' operation of the New York, New Haven & Hartford Railroad have developed so many unforeseen troubles, when applied to such a large enterprise, as to bring upon it much adverse criticism. On the other hand, the high degree of perfection to which the direct-current system has been brought, the greater capacity of the motors of this system and the enormous mileage already installed in tunnels and terminals have resulted in a strong advocacy of this system. Speaking generally for motors of equal weight, that of the direct-current system has 25 per cent. more capacity than that of the alternating-current system. The equipment of a high speed interuban car having four motors of approxi-

mately 100-horse-power capacity, will weigh under direct current system 22,500 pounds and under the alternating system 32,000 pounds, or nearly 50 per cent. excess over the direct-current equipment. For the entire car, however, the excess weight would be only about 12 per cent. The excess in cost would be about 35 per cent. In the case of locomotives the excess weight of the alternating-current equipment is even greater. The New York, New Haven & Hartford alternating locomotive has about the same weight as the New York Central direct-current locomotive, but if compared on the basis of maximum tractive effort the former weighs twice as much. The two locomotives are, however, designed for different service and the comparison is much more favorable to the alternating-current system if based on the continuous capacity. The cost of each of these locomotives is about the same.

Taking a broad view of the situation at present, we find that the direct-current system is already installed and continues to be favored for dense, short-haul traffic, such as is found in city terminals and tunnels, and short suburban service. This is largely due to the greater familiarity with the direct-current motor, to its greater capacity and less cost. It is admitted, however, that this system will not do for through traffic over long distance. The single-phase system possesses marked advantages for long haul, express and passenger service on account of the great saving effected in line conductors and sub-stations. It has the great additional advantage that it can operate on direct currents also and may, therefore, enter terminals already equipped with direct current. There is every indication that the operation of steam railways by electricity will be rapidly extended within the next few years. It appears probable that the single-phase, high-voltage, alternating-current trolley will be used and that for some time direct current will continue to be used in terminals. The tendency, however, will be to abandon direct current in terminals, substituting the high voltage trolley throughout.

The process of change to electricity, however, must necessarily be gradual. The necessary capital investment must be provided for and this will probably be accomplished in any large instance by doing the work piece-meal and charging the cost to renewals. Methods for handling freight traffic have not yet been thoroughly developed. Much freight hauling is done by electricity, but before the bulk of traffic of a through line can be handled some method of multiple operation must be devised for freight trains and the work must be experimented upon by applying the methods at present indicated, to some large project. The standardization of electric railway apparatus is one of the greatest necessities of the present situation. No extensive system would care to operate its trains without the possibility of the exchange of cars with

neighboring systems and until railway engineers are agreed as to the fundamental questions of frequency and methods of train control it is probable that no large project will be put in hand. A further opposition to be met is the mass of present-day, steam-railway methods and prejudices. The steam railway has a long history and each system has its highly-trained corps of operating engineers. Electrical operation introduces many new points of view, old dangers disappear and new precautions have to be taken. Besides these matters, there are various less important disturbances to steam practise which will have to be provided for, among the most serious of which are the clearances of the third rail and trolley at crossings and at overhead structures; the clearances on draw-bridges and the methods of leading currents through such bridges; new splice bars to accommodate rail bonds and the tell-tale for notifying a brakeman on top of the car of a low bridge ahead. It seems probable that the next step in this development will be the progressive equipment of a complete system involving through traffic over long distances, with its attendant feeder and branch lines. When such a system is once installed and the minor difficulties above enumerated developed and overcome, a rapid application of electricity for steam operation will follow.

THE INFLUENCE OF RADIUM RAYS ON A FEW LIFE PROCESSES OF PLANTS[1]

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THE purpose of the present paper is to present in non-technical form some of the more striking results embodied in the author's memoir on "Effects of the Rays of Radium on Plants."[2]

It is now well known that radioactivity was discovered by Henri Becquerel in 1896. Earlier in this same year Niewenglowski had found that several substances, after being exposed to sunlight, gave off a new kind of rays that could penetrate matter opaque to ordinary light. Following up this work, Becquerel found that the salts of uranium gave off such rays, even when not exposed to sunlight. Uranium, he said, manifests a kind of "invisible phosphorescence." It was Madame Curie who, in 1898, proposed the term "radioactive" for substances possessing this property. In 1898, also, M. and Mme. Curie and Bémont announced the discovery of a new substance *fortement radio-active,* contained in pitchblende. In a moment of inspiration they named it *radium.*

The discovery of radioactivity and of radium introduced a new epoch into physical science. Not only was it necessary to revise old ideas and ways of expressing them, but new ideas and conceptions, and a new scientific jargon all developed in less than a decade. Atom, affinity, opaque, ray, electricity, matter and other more or less fundamental terms had to be redefined. To the layman, getting his science largely from the daily press, it was revolution; but to the patient worker in the laboratory it was evolution. He welcomed the new light as the sure reward of years of patient interrogation of nature; as the culmination of a long series of painstaking investigations.

Through the further classical researches of the two Curies, of Rutherford, Righi, Soddy, Becquerel and many others, the new science of radioactivity rapidly developed. The term atom became a figure of speech; matter and electricity became difficult to distinguish from each other, and what remained of scientific materialism received a blow from which it may never recover.

It need hardly be restated here, that radioactivity is an expression of the disintegration of atoms. The atom of radium is constantly breaking up and hurling into space minute particles at enormous

[1] Contributions from the Botanical Department of the University of Missouri. No. 16.

[2] *Mem. N. Y. Bot. Gard.,* 4: 1–286, November, 1908.

velocities. The smallest of these particles, one one-thousandth the size of a hydrogen atom, bear negative charges (or, shall we say, *are* negative charges) of electricity, and are called electrons. They travel with about 95 per cent. of the velocity of light, penetrate "opaque" bodies, passing easily between and through their atoms, darken a photographic negative, and to a slight extent ionize a gas through which they pass. Streams of these particles constitute the β rays of radium and other radioactive substances.

The larger particles projected from radioactive bodies are about twice the size of a hydrogen atom, or two thousand times as big as the β particles. They move more slowly than the latter, and carry a charge of positive electricity. On account of their relatively greater size, they are much more effective ionizers, and correspondingly less penetrating to "opaque" matter than the β particles. They were named α particles by Rutherford. Streams of them constitute α rays.

Whenever a β particle, or electron, is started or stopped a penetrating electro-magnetic pulse in the ether (X ray) is developed. Such rays proceeding from radium are called γ rays. In addition to the emission of one or more of these three kinds of rays, radioactive materials give off a radioactive gas, called the emanation. In studying the physiological effects of radium, therefore, we have to consider these four factors—α rays, β rays, γ rays and emanation.

Our interest in the effects of radium rays on living organisms is enhanced by the discovery that radioactivity is widely distributed in nature. It is probable that all plants and animals are adjusted to a normal degree of radioactivity in their environment, or, in other words, are in a state of *radiotonus*. Professor J. J. Thomson was the first to discover that air bubbled through Cambridge (England) tap-water became decidedly radioactive, and the subsequent researches of numerous other physicists have taught us that this property belongs to the waters of most deep wells, to mineral waters generally, to freshly fallen rain and snow, to the spray at the foot of waterfalls, to the water of the ocean in certain localities, and quite probably to all spring waters.

After Elster and Geitel found radioactivity a property of the "fango," or mud from the hot springs of Battaglia, in northern Italy, other investigators discovered the same property in mud from various widely separated sources, in lava from volcanoes, in the sediments of springs, the sand of the seashore, and in sedimentary rocks.

The discovery, also made by Elster and Geitel, of the presence of radioactivity in the earth's atmosphere has been abundantly confirmed. Soil-air is more strongly radioactive than air above the surface. Evidence leads to the conclusion that the radioactivity of water, air, mud, rocks, etc., is due to the presence of the emanation of radium and other radioactive substances.

Radioactivity, therefore, must be recognized as a factor of plant

environment, and plant physiology and the newer physics join hands. Here, as elsewhere, the boundaries between the different "sciences" break down.

Fig. 1 is from a photograph of a few of the preparations employed in the experiments about to be described. The three marked *R* are sealed glass tubes containing radium bromide. The figures indicate the degree of activity of the preparations in terms of the activity of uranium taken as a unit. Radium bromide of 1,800,000 activity is the purest salt thus far obtained. The lower right-hand tube contains radio-tellurium, which gives off only α rays.

The rod below the tubes is of celluloid, coated on one end with radium bromide of 25,000 activity. The radium coating is overlaid with one of celloidin for purposes of protection.

By means of the rod, not only the three kinds of rays, but the emanation as well, are available. The walls of the sealed glass tubes permit the β and γ rays to pass, but the emanation and the α rays not at all.

Radium coatings, such as those on the rod, were devised by Mr. Hugo Lieber, of New York City, and are a valuable aid in studying the physiological rôle of radium. The experiments of the writer, carried on for over three years at the New York Botanical Garden, were made possible solely through the great liberality of Mr. Lieber, who freely supplied all the standard preparations, several thousand dollars worth in all.

In none of the experiments did the radium itself come in contact with the plant tissues. The results noted were due to the action of the rays alone. When the sealed glass tubes were used, the effect was produced by the β and γ rays, acting together; when the radium coatings were employed, by the combined action of the emanation and the rays, α, β and γ.

To review the results obtained by other investigators is beyond the scope and purpose of the present article. Koernicke, Dixon and Wighman, A. B. Greene, Guilleminot and Abbe, not to mention others, have experimented on the action of radium rays on germination and growth, and, to a slight extent, upon other plant processes. There seems to be general agreement among them that the rays exert a retarding or an inhibiting effect, depending upon the activity of the preparation employed and the duration of exposure to the rays.

Germination is easily retarded or inhibited by exposing seeds while dry, or during imbibition of water. In one experiment ten seeds of "Lincoln" oats, after being soaked in water overnight, were exposed for eighteen hours to rays from the tube of 10,000 activity, by being placed with their embryo-sides in contact with the tube. Germination was retarded by this treatment. After being exposed for about 50 hours longer to the same preparation (67 hrs. 35 min. in all), the

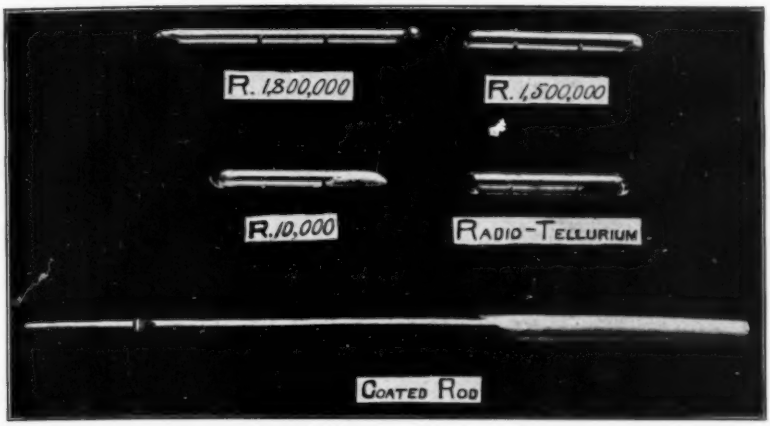

FIG. 1.

seeds, together with ten unexposed, but otherwise similarly treated seeds, were planted in soil in pots. The relative amount of growth in the two cultures at the end of five days after planting is illustrated in Fig. 2, where *R* is the culture exposed to the rays, and *C* the control (unexposed) culture. The growth of the root system was also greatly retarded by this treatment, and the root hairs on seedlings from exposed seeds were much longer than normally.

The effect of duration of exposure on the germination and growth of lupines (*Lupinus albus*) is shown in Fig. 3. The activity of the radium was the same in each case, 1,800,000, the seeds were exposed dry, and the length of exposure, from left to right in the figure, was 72 hours, 50 hours, 26 hours, 0 hours (control). The size of the largest seedling in the pan at the left doubtless indicates that the seed

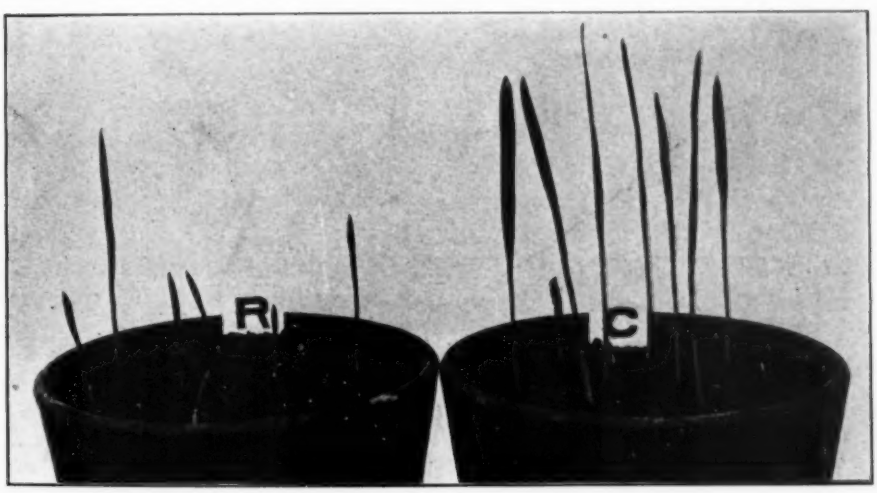

 FIG. 2.

was poorly exposed. There is usually more or less difference in the resistance of individuals, but never as much as that apparently indicated, in the 72-hour culture. This and similar experiments confirm the results of Koernicke and others that the effect varies directly with the duration of exposure.

FIG. 3.

The relative effect of preparations of different activities is illustrated by the following typical experiment. Three sets, *a*, *b* and *c*, of six dry seeds of the white lupine were exposed to rays from sealed glass tubes of radium bromide by laying the tubes in contact with the hilum edges of the seeds. Care was taken to have the radium salt distributed evenly along the bottom of the horizontally placed tube. The activities of the preparations were: *a*, 1,800,000; *b*, 1,500,000; *c*, 10,000. A fourth set, *d*, served as a control. All exposures were for 91.5 hours. The seeds were then sown in soil in pots, and the comparative amounts of growth in the four cultures are shown in Fig. 4. The activity decreased from left to right. It is clearly demonstrated that the stronger the activity the greater the amount of retardation, under the conditions of the experiment.

FIG. 4.

An experiment to test the effect of a radioactive atmosphere on germination and growth was facilitated by the preparation by Mr. Lieber of a tube lined with the radium coating devised by him. This tube (*T*, Fig. 5) was connected with the upper tubulure of a glass bell-jar, resting air tight on a ground-glass plate. The lower tubulure was connected with an exhaust, so that air, entering the radium-lined cylinder, carried with it into the bell-jar the radioactive emana-

tion. This air was delivered over pots of growing plants or freshly planted seeds in various ways, one of which is shown in Fig. 5, where the radioactive air passed over the soil-surface from an ordinary dove-

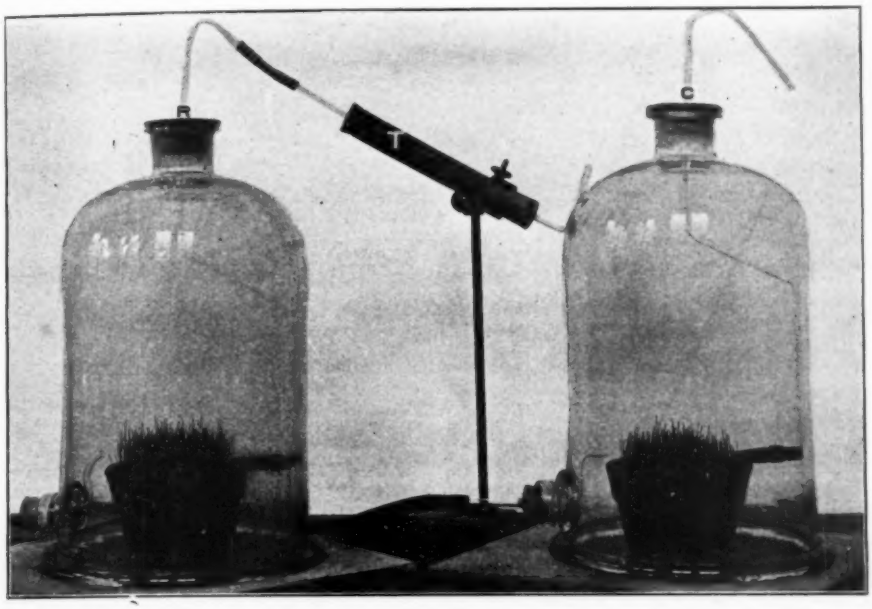

FIG. 5.

tail gas burner. The opening to the outlet pipe is under the flower pot. A control apparatus was similarly arranged, with the exception of the omission of the radium preparation. In one experiment, after a six days' exposure of timothy grass seed, sown unsoaked and covered with only an extremely thin layer of soil, germination and growth were shown to be retarded and the amount of retardation was greatest nearest the point of delivery of the radioactive air (Fig. 6). But where germinated seeds of the white lupine, with radicles marked 10

FIG. 6.

mm. back from the root-tip, were exposed for twelve hours in the radioactive atmosphere, growth was greater than that of a like number of roots similarly placed in the control jar. In one experiment, for

example, the total growth in 24 hours was, for the exposed radicles, 28.66 mm., and for the control radicles only 16.08 mm.

Thus it is seen that exposure to radium rays, though followed in some cases by a retardation or inhibition of function may, under certain suitable conditions of exposure and with certain tissues, be followed by an acceleration.

Excitation of function is further illustrated by the following experiment: In a flower pot of soil unsoaked seeds of oat were sown in three concentric circles, distant, respectively, 7 mm., 22 mm. and 45 mm. from the center of the pot. Into the soil at the center was inserted the sealed glass tube of radium bromide of 1,500,000 activity. The end containing the radium was about 15 mm. below the soil surface. A second pot was arranged in a like manner except for the substitution of an empty glass tube for the radium tube. At the end of 106 hours the seedlings from the exposed seeds were much taller

FIG. 7.

than those in the control pot (Fig. 7), the amount of stimulation being greatest in the outer circle of plants and least in the inner circle. At the end of the 106-hour period the radium tube was placed in the control pot and the empty glass tube in the pot *R*. Following this change the seedlings in *CR* grew faster than those in *R*, now serving as a control. Thus it was possible to accelerate the growth of the seedlings in either pot at will by transferring the radium tube from one culture to the other.

The fact that incandescent gas mantles contain a large percentage of thorium, a radioactive substance, suggested the following experiment. On the surface of soil in a pot was sown a row of timothy grass seed, and over this row and at right angles to it, was suspended a fresh, unburned mantle at a distance of three or four millimeters above the seeds (Fig. 8). Germination and subsequent growth were both re-

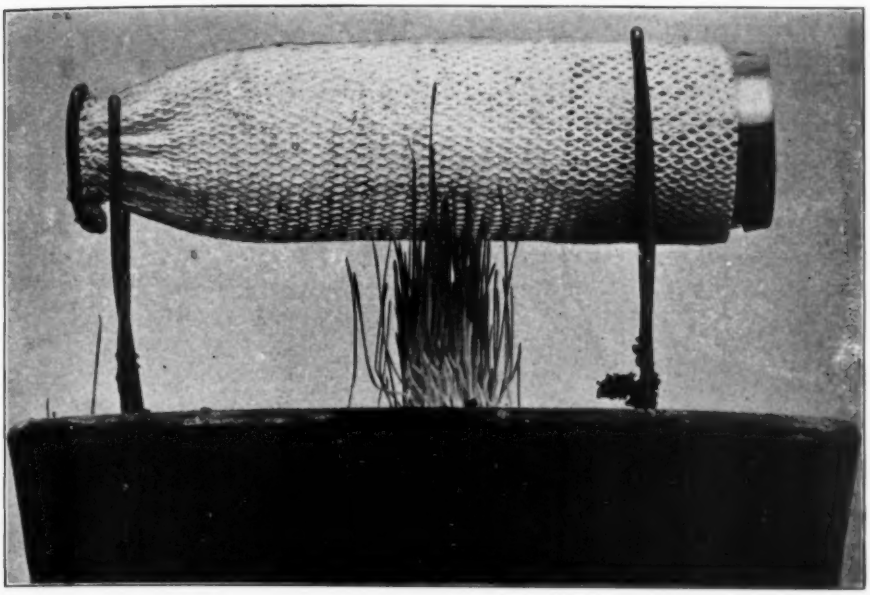

FIG. 8.

tarded by the rays from the mantle, and Fig. 9 shows the appearance of the culture seven days after the experiment was started.

The influence of radium rays on photosynthesis was tested in several ways. For example: A nasturtium (*Tropæolum*) plant was placed in sunlight after having been in darkness for 18 hours. Under one of the leaves, and lightly in contact with it, was placed a Lieber's coated rod of undetermined (probably 25,000) activity. After twenty-four hours the leaf was dechlorophyllized and stained with iodine to test the presence of starch. Starch was almost entirely wanting in the part of the leaf that was directly over the radium-coated rod, but was

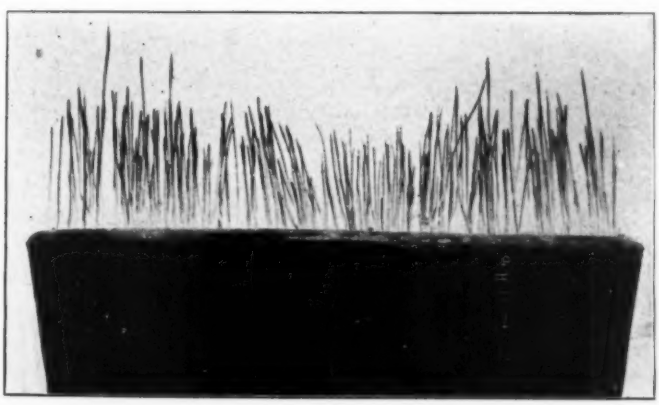

FIG. 9.

present in other portions of the leaf. The result was recorded by exposing the leaf to sunlight in contact with the velox paper in a printing frame. The region lacking starch, being more translucent, gave the darkest image on the velox paper (Fig. 10).

It was found possible to increase the rate of respiration of germinating seeds by means of the rays, and alcoholic fermentation was also accelerated by suitable exposure, as follows: Five fermentation tubes were filled with equal quantities of a mixture of 2 gm. of a compressed yeast cake in 250 c.c. of a 5 per cent. solution of cane-sugar. Into four of the fermentation tubes were placed sealed glass tubes as follows: $RaBr_2$ 1,500,000 ×; 10,000 ×; 7,000 ×; radio-tellurium. The fifth served as a control. At the end of about three and one half hours the cultures were photographed (Fig. 11). It is clearly shown in the figure that the rate of alcoholic fermentation, as measured by the evolution of gas, was accelerated by the rays; most by the preparation of 1,500,000 activity, least by that of 7,000 activity, and to an intermediate degree by the other preparations.

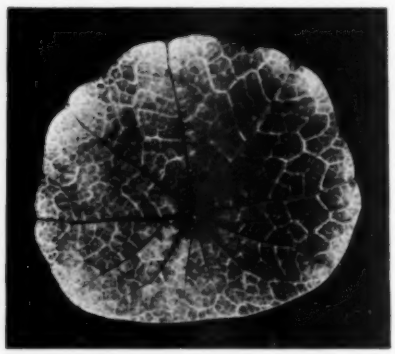

FIG. 10.

Various attempts have been made to detect a tropistic response, or curvature of a growing organ toward or from a radioactive source. The phosphorescent light of radium has not been found intense enough to call forth phototropic curvatures, and the existence of a true *radiotropism* is yet to be demonstrated. Koernicke found that seedlings

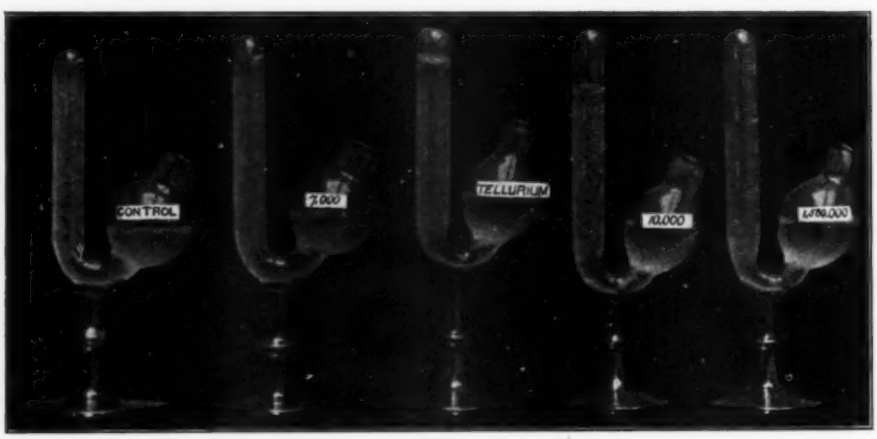

FIG. 11.

grown from exposed seeds were still sensitive to gravity and unilateral illumination, and the experiments of the writer confirm this result. Under certain conditions of exposure of corn grains, however, the seedlings failed to respond to gravity, and grew horizontally, close to

FIG. 12.

the soil surface. Thus, in one experiment, the grains were exposed for twenty-seven hours to rays from radium bromide of 1,800,000 activity, and all of them showed this tendency to a greater or less degree (Fig. 12, pot 27). Whether geotropic sensibility was destroyed by the exposure is difficult to say, for histological examination showed the tissues to be so abnormal that it is possible the plants could not have stood erect even if they had been able to detect the stimulus of gravity.

All attempts to obtain a curvature of growing organs or plants toward or from a radium tube or radium-coated rod proved unsuccessful, but when a sealed glass tube of radium bromide is suspended hori-

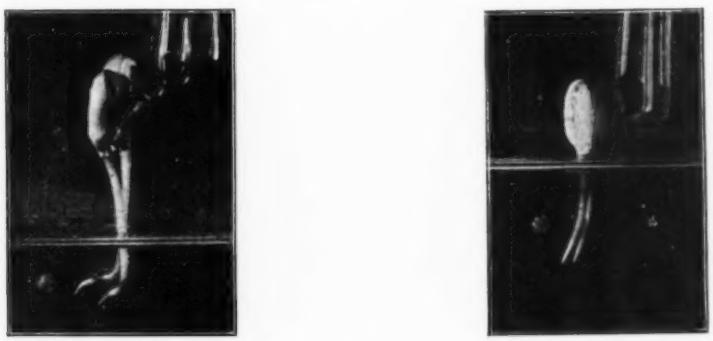

FIG. 13.

zontally in tap-water, or in nutrient solution, in which radicles of white lupine seedlings are growing vertically, the tips of the roots may be made to curve toward the radium. Such a result is illustrated in Fig. 13. In this experiment the radium tube was originally about 5 mm. distant from the root-tips. Whether this result was due to the direct influence of the rays, or to some undetermined condition established by them in the liquid can not yet be decided.

The above experiments were all confirmed by repetitions, and clearly indicate that radium rays act as a stimulus to the various physiological processes of plants. If the strength of the radium, the duration of exposure, and other conditions are suitable, the response is an excitation of function, but if the method of treatment is otherwise, the radium too strong, the exposure too prolonged, the result is a retardation, or complete inhibition of function, or the death of the plant. There are not only differences in sensitiveness between individuals, but also between different species and different tissues. As in the case of animals, embryonic and younger tissues are more sensitive than those that are older and more mature.

THE WORK OF BOARDS OF HEALTH[1]

By Dr. GEORGE A. SOPER
NEW YORK CITY

THE spirit of the laws by which matters of public health are administered rests upon the theory which underlies all forms of government, that is, that the state has the power to compel the ignorant, the selfish, the careless and the vicious to so regulate their lives and property that they shall not be a source of danger to others. It is an expression of the idea that the interests of no man can exceed the interests of his fellows. The welfare of the many is the supreme law.

Extraordinary powers have from early times been vested in the authorities charged with administering sanitary laws. The highest courts have declared that the administration of public health laws is fundamentally important and entitled to the support of the police power of the state. Public health authorities are in effect police officers charged with a special jurisdiction over the conditions which cause, aggravate or predispose to disease. In the exercise of their remarkable powers health authorities may restrain persons from contact with others, they may enter upon and even destroy private property and may exercise supervisory jurisdiction over trades and occupations.

Many years ago, the almost autocratic power enjoyed by health authorities was much more necessary than it is at present, for the highly contagious diseases have, through the operation of health laws, better personal and household hygiene and municipal sanitary works, been relegated to a comparatively unimportant place as a cause of death. Epidemics of high mortality and vast extent rarely take place in civilized countries to-day, and the need of a prompt, decisive exercise of great authority in this direction is consequently less often necessary than formerly.

At the same time, a new class of duties is growing upon health authorities. Some of these duties are plainly within the proper functions of health boards, while others appear to be less so. Among the obviously proper duties referred to are vaccination, the manufacture and distribution of antitoxin, the control of methods of sewage disposal and the sanitary management of milk and water supplies. Of less obvious appropriateness is the regulation by boards of health of such matters as the discharge of excessive quantities of smoke into the atmosphere of cities, the suppression of street noises, the hygienic care

[1] Paper read before a joint meeting of the National Municipal League and the American Civic Association at Pittsburg, Pa., November 16, 1908.

of the food, clothing, exercises and amusements of school children. It is probable that these matters should be made the subject of regulation in the public interest, but should the board of health be the instrument chosen to regulate them?

Obviously some limit should be placed upon the exercise of the power possessed by boards of health when questions not strictly germane to the sanitary welfare of the public are concerned. If no such limit is placed, it is difficult to understand where the activities of boards of health are to cease. Almost every act and occupation and nearly every feature of city life may be construed as having some bearing upon public health and welfare. Before a board of health sets out upon a campaign of more esthetic than sanitary value it should be certain that all its simple and essential duties are being efficiently discharged. There is often much inconsistency in public health work.

So extensive and so numerous are the conditions of modern civilization which certainly affect health, that boards of health generally do not pretend to cover them all. For example, the construction and maintenance of public water supplies and sewerage systems, although undertaken by the public at the public expense, are not conducted by health authorities but by private corporations or special municipal departments. Likewise the collection and disposal of garbage, and even the cleaning of privies, is often done by other than public health authorities.

There is something incongruous about a board of health conducting a crusade against smoke and noise and at the same time allowing the streets to be filthy with dirt and dust and offensive with accumulations of fermenting garbage. Again a great deal of the attention of health boards is occupied with alleged private nuisances which affect comfort but not health. The history of every city is a record of more and more strict regulations to minimize the unpleasant as well as the unsanitary conditions of household life.

The work of boards of health has been, on the whole, very decidedly for the advancement of the general welfare. The great reduction in the general death rate and the more wholesome and agreeable conditions of living of to-day as compared with those of a generation ago, bear ample testimony to this success. If it be objected that other factors have been at work to improve the sanitary conditions of cities, it must be answered that much of the inspiration for this other work has come from health authorities. It should never be forgotten that it is sanitation which has made the growth of cities possible.

Having thus briefly referred to the scope and bearing of public health work we may pass to a consideration of the relation of city, state and nation in protecting the public health.

The authority exercised by public health boards is derivable from

the state. In the United States the management of the internal affairs of each separate state is left, for the most part, to the state concerned. Municipal charters are obtained from the state governments and in these charters the power to regulate conditions affecting public health are specifically granted. Cities and towns thus owe responsibility to the state governments and are answerable to them to a greater or less extent, depending upon local circumstances. In Massachusetts local boards of health are comparatively independent of the state authority, while in New York the state department of health is a central body to which the local boards of health are closely tributary.

State health authorities are in no case responsible or answerable to the general government. There is no national board of health.

In the management of health matters the smallest unit of responsibility is a municipal health officer or municipal board of health; the largest the state health officer or board of health. Whether municipal or state, the functions of health authorities are very much the same. The main differences arise from the differences in area over which the authorities are required to exercise supervision. Local boards have charge of the conditions which occur in the several localities in a state; they take cognizance of individual houses and of persons. The ultimate units over which state boards exercise jurisdiction are municipalities.

It is the first duty of all health boards to collect vital statistics, to collate them in tabular form, and to interpret these data so as to show the state of the public health. Local boards of health collect reports of deaths and of contagious and other diseases from physicians, interpret these data, for the benefit of the districts in which they apply, and then forward them to the state authorities. The state authorities so obtain a knowledge of the health in various sections of the state and are so enabled to judge the relative healthfulness of the different localities. An excessive prevalence of disease in one place can thus be promptly detected.

The methods of collecting vital statistics are often unsatisfactory and the results frequently deceptive. It may be remarked in passing that vital statistics are to-day available for only a part of the people of the United States, except during years when this government makes a census enumeration. The census returns are themselves unsatisfactory. In this respect the United States government is behind nearly every civilized country in Europe. The fault lies with our municipal and state governments.

In interpreting death rates careful account must be taken of the marriage and birth rates, total population, migrations of population, and other factors; and it would be well for boards of health to charge themselves with collating as well as collecting these vital statistics, in a more intelligent manner.

When the evidence of vital statistics indicates the presence of an unsanitary condition through an excessive prevalence of some communicable disease, investigations are commonly made to determine the nature of the difficulty. This is often a troublesome and uncertain task. But when the difficulty is once discovered it is usually a simple matter to prescribe the remedy.

In very recent years sanitary investigations have been made much more definite and effective by the applications of bacteriology, chemistry and pathology, and a new class of professional men has been developed for laboratory and field work of the highest and best order. These persons we may call sanitarians or, better, hygienists.

The second main branch of public health work is the suppression of communicable diseases. Suppressive measures include the establishment of quarantine, the isolation of patients, disinfection, vaccination and the management of epidemics. Contrary to the custom of twenty years ago, all the best work in these directions to-day is based upon a scientific knowledge of what we may call the natural history of disease. In all these matters of control the dictum of the health authority is supreme. It can be resisted only through intervention by the courts.

The third main branch of public health work is the abatement of nuisances. The practical work of suppressing unsanitary conditions is done by health authorities by recourse to special statutes and local regulations made by the authorities themselves and termed "sanitary ordinances" or "sanitary codes." Offenders against these laws and regulations are brought before proper magistrates and fined. A board of health exercises the unique function of both making and enforcing the law.

It may be extremely difficult to determine what does and what does not constitute a nuisance. For practical purposes it is often considered that anything which is detrimental to health or which threatens danger to persons or property may be considered and dealt with as a nuisance.

Interesting work for the suppression of disease lies in educating the public, the medical profession and the health authorities as to the causes of and means of preventing the transmission of disease germs. This is one of the newest and most successful branches of public health work which has been undertaken for many years. It is based on the fact that people are not careless in sanitary matters because of a wilful or vicious design against the public welfare; they err through ignorance. By educating the less fortunate concerning the ways in which diseases are transmitted and showing how they can be prevented, substantial benefit results.

This educational work is carried on by the daily papers, the medical papers, special bulletins and magazines, by lectures, by clinics, by congresses and, to some extent, by schools. Sanitary societies and public

health associations deserve special credit for good work in arousing the public to the need of better public health work.

At the same time it is regrettable that arguments have been made and movements have been initiated in the name of public health which have had no foundation in fact or scientific principle. The cause of public health has always been a favorite theme alike for the charlatan and the statesman.

By the remarkable advance in that composite body of knowledge known as sanitary science much of the quackery of fraud and the deceptions of ignorance are being dispelled from public health work, and we may confidently look forward to the time when persons who have had adequate training and experience in this direction will be looked upon as the proper sanitary teachers.

In the campaign of sanitary education which is going on it is a deplorable fact that the universities and colleges of the United States are singularly backward. With a few notable exceptions, there is scarcely a school for higher education in the United States where a competent knowledge of hygiene can be obtained. In spite of the fact that many of the largest and most prominent universities have had severe experiences with typhoid they have been exceedingly slow in providing proper facilities for the teaching of hygiene. One of the greatest needs of to-day is the want of competent teaching for health officers, physicians, engineers and others, who may wish to obtain a complete and practical knowledge of their profession. In the absence of suitable facilities for the education of health officers the United States is decidedly behind European countries.

In the management of communicable diseases the principles of isolation, disinfection and vaccination, have been referred to. It remains to mention the help that may be afforded by the establishment of laboratories for the diagnosis of suspected cases of communicable diseases. Laboratories where examinations may be made of sputum, blood, urine, stools and other pathological specimens, are one of the newest developments in public health work, but they have been in operation sufficiently long to make them seem indispensable. By their means early and obscure cases of tuberculosis, typhoid fever, diphtheria and other too common preventable diseases may be discovered, and with a precision and promptness generally impossible in private medical practise. Along with pathological work of municipal public health laboratories facilities are often provided for the analysis of water, milk, food and drugs. Any citizen may send specimens to these laboratories for examination, and is entitled to a report without charge.

Every board of health should have the benefit of laboratory assistance of this kind. Municipal boards in large cities can afford to maintain them, but for the small city and village other provision must

be made. Here the state can render valuable assistance and maintain laboratories for the benefit of municipalities which can not have them.

In addition to the measures of prevention and suppression which have been mentioned reference should be made to the preparation and distribution of antitoxin by boards of health. Here we have an application of the laboratory principle applied to the production of a remedy rather than to the discovery of the cause of disease. Antitoxin is a curative measure which may be and is applied more often than not to isolated cases of diphtheria. The beneficent results which have followed the use of this agent in combating one of the most common and fatal of household diseases are unquestioned, but it must not be forgotten that in supplying antitoxin without charge, boards of health lay themselves open to the charge of competing with private manufactories which prepare the same product and are presumably in a legitimate business to make money.

Results seem to show that it is desirable for boards of health to supply antitoxin, but the principle involved is an interesting one. If antitoxin is to be supplied gratis by boards of health, should not those boards also supply disinfectants, concerning which there are no greater frauds in the American markets to-day? And if antitoxin and disinfectants, why not other things such as indispensable articles of clothing?

To enumerate all the functions of boards of health, local and state, would far surpass the necessary limits of this paper, but enough has been said to show warrant for endorsing most of the work being done to approve the extension of some and the limitation of others of the ever-growing activities of health bureaus. A long paper could be written on any of a dozen phases of this subject.

Taking a rapid review of the subjects covered here, we may remark first that boards of health have ample power. The standards of public health and municipal hygiene are continually growing higher.

The dangers from disease in gross epidemic form are becoming less and less, and in their place a new set of hygienic standards is being erected. Some of these new standards verge upon the realm of esthetics. To what extent boards of health are right in extending their efforts to improve municipal conditions which bear remotely, if at all, on disease and death, but undoubtedly affect public comfort, is a question for debate.

To be effective health work must be cooperative. Statistics must be promptly and accurately collected by the ultimate units of sanitary authority, municipal health boards, and transmitted to boards having jurisdiction over larger territory. Whether or not the largest unit of health control should be the state or the nation is a question which this paper need not discuss. It is to be remembered in this connection, however, that state boundaries are only imaginary lines and that some

kind of understanding is indispensable between neighboring states for some forms of sanitary control, such, for example, as the purity of water supplies, the management of epidemics and the regulation of milk and other food products. Likewise the management of quarantine, a subject of importance to large portions of the population of the nation, should not be left to the regulation of any particular locality, but should be managed in accordance with laws which are general for the common welfare.

First and foremost among the defects and needs of public health administration must be placed the want of adequate knowledge of the principles and practises of public health work on the part of officials having jurisdiction. It is a deplorable fact that special professional qualifications are not as a rule required of health officers in the United States.

If there is any department of municipal government which should be taken out of politics and put upon a high plane of professional efficiency, it is public health work. Generally, in the United States, appointment upon a health board means a thankless and gratuitous service performed for the sake of the small honor which is supposed to go with it. Where a salary is connected with the position the office is too often a reward of political rather than professional merit.

Until the need of high-class health work is demanded, appreciated and properly rewarded by compensation in money and honor, men will not be prepared by the schools for a life-work in the public health service, and the most needed improvement in the work of boards of health will not be made.

A BIOGRAPHICAL HISTORY OF BOTANY AT ST. LOUIS, MISSOURI. IV

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U. S. DEPARTMENT OF AGRICULTURE

ONE of the best known of the botanical collectors of this country who worked shortly after the middle of the last century was August Fendler. He, like numerous others, came to America from Germany in the late thirties. From 1864 to 1871 he lived at Allenton, Missouri, about thirty miles from St. Louis. While living at Allenton Fendler arranged the first botanical specimens in the herbarium which was just being started by Henry Shaw for his Botanical Garden. These numbered about 60,000 and consisted of the herbaria of Bernhardi and Riehl, the latter containing a considerable number of local species. Because of his extensive and excellent collections, he became known to botanists and botanical institutions. While he was widely known by reputation, he seems not to have been well known personally, because of his excessive diffidence.

August Fendler[17] was born August 10, 1813, in the town of Gumbinnen, in eastern Prussia. When he was six months old his father died, and two years later his mother married again. His parents had but scanty means and his school training for a number of years could scarcely be called schooling. When about twelve years old he was sent to the Gymnasium, and was here for about four years, when his parents were obliged to take him from school because of financial troubles. He was apprenticed to the town clerk's office, and here began to think of traveling in foreign countries.

At the end of his apprenticeship he had an offer to accompany a prominent physician as his clerk in a journey of inspection along the Russian frontier of Prussia where the cholera was beginning to be feared. Fendler was soon in the midst of the cholera and remained for some time, returning home when the disease had abated. He now learned the trade of tanning and currying during the next two years. In the fall of 1834 Fendler was admitted to the Royal Gewerbeschule, but the strain upon his already frail health caused him to abandon it after finishing the first year with credit.

[17] Canby, W. M., *Bot. Gaz.*, 9: 111–112, 1884; 10: 285–290, 301–304, 319–322, 1885.

Gray, Asa, *Amer. Jour. Sci. and Arts*, 3d series, 29: 169–171, 1885.

Sargent, C. S., "Silva of North America," 12: 123–124, 1898.

In the fall of 1835 he started with a knapsack upon his back from Berlin as a traveling artisan, passed through parts of Silesia, Saxony, to Frankfort, down the Rhine, and finally coming to Bremen. Early in the spring of 1836 he embarked for Baltimore, Maryland, arriving with but two dollars in his pocket. In Philadelphia he worked in a tannery

FIG. 13. MR. AUGUST FENDLER, at about the time he lived at Allenton, Mo.

for a time, then went to New York and worked at the lamp manufacturing business. The financial panic of 1837 caused this business to be closed in the spring of 1838.

Having made up his mind to go to St. Louis, he started as soon as possible. The easiest way was from New York to Albany by boat, thence to Buffalo by canal, to Cleveland by steamer, to Portsmouth on the Ohio River, and then down the Ohio and up the Mississippi by steamboat. This trip took thirty days.

In St. Louis, which had then about 13,000 inhabitants, he soon got employment, but decided to go to New Orleans because of the approaching winter. He left St. Louis about Christmas, 1838, on foot, with his knapsack on his back; he crossed the Mississippi and walked along through the thinly settled forests of Illinois, the cane-brakes of Kentucky, and a part of Tennessee, where he fell in with two others going to the same destination. At the mouth of the Ohio they joined in buy-

ing a skiff and set out for New Orleans in it. They soon were caught by a steamer going their way and they boarded her and abandoned their skiff. Upon arriving in New Orleans the talk about Texas decided him to go farther west, and he arrived in Galveston in January, 1839. He stayed in Texas about a year and then returned to Illinois where he taught school for some time.

In the fall of 1841 he found an uninhabited island in the Missouri about three hundred miles above St. Louis, and he took up his solitary residence there. When the spring rise came it caused him to leave.

In 1844 he sailed for home, and while on this trip first learned that sets of dried plants might be sold. On his return to America and to St. Louis he began to collect and was aided by Dr. Engelmann in naming his specimens. He visited different parts of the country between Chicago and New Orleans for the purpose of collecting. Dr. Engelmann commended him to Dr. Asa Gray, and he was furnished with the authority to accompany some troops which were being sent to Santa Fé, so that he had free transportation for himself and luggage. He returned to St Louis in the fall of 1847. In the spring of 1849 he started on another collecting trip to the West. He was unsuccessful, having lost most of his stock of drying papers in a flood, and he was forced to return to St. Louis. Upon his arrival here he found that all of his large collections and notes and journals had been destroyed in the great fire which burned much of the business section of the city during his absence. In 1849 he embarked for Panama, and after four months again returned to Arkansas, and finally went to Memphis, where he went into business. In 1854 he went to Venezuela and collected for four years, during this time exploring alone mountain ranges which were scarcely known at that time. He made very large collections, which are of great value. He returned to Missouri in 1864 and bought a tract of land in the town of Allenton, about thirty miles west of St. Louis. This he began to clear and cultivate in company with his half-brother, who was half-witted, and who always was dependent upon him. Here he remained for seven years, with the exception of a month spent in the Gray Herbarium, assisting in its arrangement. During this time Mr. Letterman became acquainted with him, and from 1870 to 1871 they met two or three times a week and nearly every Sunday with green plants to be identified. He seems to have collected but little in the vicinity, but was very familiar with the plants of the general neighborhood. After clearing his land and putting up his house, mostly with his own hands, he spent most of his time writing a book. This is undoubtedly his "Mechanism of the Universe," which was unfortunately published at his own expense later. Failing health forced him to dispose of his farm and remove to another climate. In 1871 he sold the farm and left for Europe, intending to live there the rest of his days. He, however, returned and

settled at Wilmington, Delaware, in 1873. While here he finished his book and published it. Repeated attacks of rheumatism compelled him to seek a warmer climate, and he and his brother went to the island of Trinidad. They lived at Port of Spain, landing in June, 1877; here the remainder of his life was spent in making botanical observations and collecting, especially among the ferns. Advancing age restricted his

FIG. 14. HOUSE BUILT BY AUGUST FENDLER IN ALLENTON, MISSOURI, and occupied by him during his residence here from 1864 to 1871. The small ell has been added by subsequent owners.

efforts to the immediate neighborhood, and when this was exhausted he did but little. His death occurred in November, 1883.

An appreciation of his work from one who knew him best follows:

> It is needless to say that Fendler was a quick and keen observer and an admirable collector. He had much literary taste, and had formed a very good literary style in English, as his descriptive letters show. He was excessively diffident and shy, but courteous and most amiable, gentle and delicately refined. Many species of his own discovery commemorate his name, as also a well-marked genus, *Fendlera*, a Saxifragaceous shrub which is winning its way into ornamental cultivation.[18]

[18] Gray, Asa, *Amer. Jour. Sci. and Arts*, 3d series, 29: 169, 1885.

Dr. F. Adolph Wislizenus came to America from Germany in 1835; he landed at New York and lived there for the next two years. In 1837 he went west, settling near Belleville, Ill. Two years later he came to St. Louis and lived in that city practically all the rest of his life. He is not known to have performed any botanical work in the vicinity of St. Louis, but he is included in the present paper because of having made a very considerable collection of plants in New Mexico, Mexico, and other parts of the great American arid plain. This collection was

FIG. 15. DR. ADOLPH WISLIZENUS; by permission of the St. Louis Academy of Sciences, from a photograph in their possession.

one of the first from the region visited, and is considered especially important because Dr. Wislizenus was one of the first to give an accurate, scientific account of the sections visited by him. This is especially true of Mexico, of which there were very erroneous and distorted ideas in the United States.

Dr. Frederick Adolphus Wislizenus[19] was born in 1810 at Koenigsee, in Schwarzburg-Rudolstadt, one of the numerous tiny German principalities of that period. He was the youngest of three children of a Protestant minister whose ancestors were said to have fled from Bohemia, victims of the religious fanaticism which resulted in the persecution of Hus and his followers.

[19] Engelmann, Geo. J., *Trans. St. Louis Acad. Sci.*, 5: 464–468, 1890.
Sargent, C. S., "Silva of North America," 6: 94, 1894.
Wislizenus, F. A., "Memoir of a Tour to Northern Mexico," 1–141, 1848.
POP. SCI. MONTHLY, 52: 643, 1898.

Wislizenus studied medicine at the University of Jena in 1828, and later at Göttingen and Würzburg. He was a member of the "Burschenschaft," but escaped arrest when that was broken up by the authorities. He followed his friend and teacher, the great clinician Schoenlein, to Zürich and there joined an expedition to aid Mazzini in his struggle against Austrian rule; but the Swiss troops disarmed them on the border so he was forced to return to his studies.

Wislizenus graduated in Zürich in 1834 and soon sailed for New York, where he began to practise his profession in 1835. Here he remained two years writing constantly for the German papers of the city. He then went west in 1837 and joined some of his fellow-exiles who had settled in St. Clair County, Illinois. In 1839 he came to St. Louis and immediately seized an opportunity to accompany an expedition of the St. Louis Fur Company for trading with the Indians. He thus went far into the Northwestern country towards the source of the Green River in the Wind River Mountains. When the expedition started to return he joined a band of Flat-head and Nez Percé Indians. He thus crossed the Rocky Mountains to Utah and went as far as Fort Hall, the most southern post of the English trading company. Here he could find no guide to take him to California, so he returned; crossing the Green and the south fork of the Platte, he followed the Arkansas to Missouri. During this trip he had no facilities for making scientific observations and collections, so it was wholly without any such results.

On his return to St. Louis in 1840 he resumed his practise of medicine. He was identified with early efforts towards the establishment of an Academy of Science, and aided Dr. Engelmann in his efforts to found a botanic garden, and was an earnest worker in the Western Academy of Science. He soon gained a lucrative practice, but as soon as the opportunity offered he was again in the field. He joined a trading expedition to Mexico, well equipped this time with instruments and apparatus for scientific work. In Santa Fé they first learned of the war between Mexico and the United States, but Wislizenus obtained a pass and proceeded to Chihuahua, where he with other Americans was seized and imprisoned. He was sent to a small mountain town of the interior and there had ample opportunity to carry on his collecting and observations in the neighborhood during the winter. Upon the arrival of Col. Doniphan's troops in the spring he was released and accompanied them in a professional capacity until their disbanding at New Orleans in 1847, when he returned to St. Louis.

Senator Thomas H. Benton became interested in him and his experiences in Mexico, and finally was the cause of his being summoned to Washington and being requested to prepare for publication the results of his investigations. His resulting "Memoir of a Tour to Northern Mexico in 1846 and 1847" was considered important enough so that the senate ordered 5,000 copies printed for distribution. This publication

gave a good account of the country which was then much misunderstood and misrepresented, and resulted in correcting many erroneous ideas regarding that section of the American continent. It contained many very valuable data concerning the meteorology, geology, topography and botany of the region. Among the valuable results of this tour was a botanical collection containing many new plants which were classified and described by Dr. Geo. Engelmann, of St. Louis, who commemorated the valuable services of Wislizenus to science by applying his name to a new genus, *Wislizenia,* as well as to several of the new species of the collection.

Wislizenus again returned to St. Louis from Washington upon the completion of his report, and served faithfully during the cholera epidemic of 1849. As soon as this was over, however, he went to Constantinople in 1850 to bring back with him as his bride, Miss Lucy Crane, a sister-in-law of Hon. Geo. P. Marsh, whom he had met while in Washington. After visiting his old home in Thüringen and the large cities of the Old World, the two returned to the United States. Leaving his wife with her friends in the east, he went to Panama and California in search of a more desirable location. But he again returned to St. Louis and finally settled down permanently. He was one of the founders of the St. Louis Academy of Science and an active worker and one of the officers of the St. Louis Medical Society and of the Western Academy of Sciences. He was for many years president of the German Medical Society of St. Louis. His barometrical observations and his botanical and mineralogical collections, together with his memoir, are distinct additions to science. He was interested in meteorology from 1858 till his death, and in 1861 he commenced to study the atmospheric electricity with the belief that this would be of value in connection with meteorology. He discontinued this study, however, upon arriving at the conclusion that it was valueless in this connection—a fact which is now generally acknowledged. His last days were spent in seclusion, he being closely confined to the house by his infirmities and the loss of his sight. He died on September 22, 1889, in his eightieth year.

In 1851 there began a most important movement for the advancement of botany in St. Louis.[20] In that year, Mr. Henry Shaw, while on his last visit to Europe, first conceived the idea of establishing for himself a country estate on lines similar to those of many of the large English ones. In fact he had already started to build a home in the country district west of St. Louis.

This idea of a large private estate seems to have soon become changed to that of a botanical garden, for in 1857 he commenced active opera-

[20] Trelease, Wm., Mo. Bot. Garden Report, 1: 84–90, 1890. *Plant World,* 5: 1–4, 1902. "The Academy of Science of St. Louis," POP. SCI. MONTHLY, 62: 118–130, 1903. "The Missouri Botanical Garden," POP. SCI. MONTHLY, 62: 193–221, 1903.

tions to this end. He even at one time planned a grand school of botany with all the appendages and equipment necessary for a college of botany. This was modified in its first inception, but has been carried out to a degree. Very soon he built a botanical museum, bought herbaria and built greenhouses in which tender and exotic plants might be grown, while the grounds themselves were planted with many of the more hardy species. In 1859 he secured the passage of an act of the Missouri state legislature enabling him to deed or will to a board of trustees such property as he might wish, to be used for the maintenance of the Missouri Botanical Garden, as he prophetically named it. In 1885 he founded the Shaw School of Botany in connection with Washington University of St. Louis and provided for very close relations between the school and the garden. The estate deeded for the use of the garden was valued at about one million two hundred and fifty thousand dollars. This has increased very materially in value with the rapid rise in real estate in and about St. Louis. From the small beginnings of a private estate, the garden has developed until there were in cultivation in 1906, over seventeen thousand species and varieties of living plants; fifty-five thousand books and pamphlets in the library, including a very fine collection of pre-Linnæan works, and five hundred and sixty thousand sheets of dried specimens. The garden has issued eighteen annual reports, and is in exchange relations with nine hundred institutions interested in botany, gardening, horticulture or forestry. The library is one of the finest of the botanical libraries of the world, and all resources of the garden are placed at the free disposal of those capable of using them. Thus Mr. Shaw's life-work has reached its fruition, and a fitting memorial is rising steadily to more and more impressive proportions.

Henry Shaw[21] was born in Sheffield, England, July 24, 1800. He was the eldest of four children. His father was a manufacturer of grates, fire irons, etc., and owned a large establishment. Henry's early education was obtained at Thorne, a neighboring village, and his favorite place for study was an arbor in the garden. He was later transferred to Mill Hill, about twenty miles from London. This was termed a "dissenting" school, but was also considered one of the best private schools in the Kingdom. He remained here about six years, leaving probably in 1817, thus finishing his schooling. He studied while here considerable Greek, more Latin, more than the average amount of mathematics, French, and undoubtedly German, Italian and Spanish. With this scholastic training he began to assist his father at the home establishment for a year, after which he accompanied him to Canada. In this same year, 1818, his father sent him to New Orleans, mainly to investigate cotton raising. He stayed in Louisiana but a short time,

[21] Dimmock, Thos., *Mo. Bot. Garden Report*, 1: 7–25, 1890.

as he did not like the climate nor were there financial inducements for his doing so. He was now his own master and decided to go north and try his fortune in the then small and remote French trading post known as St. Louis. He accordingly embarked upon the *Maid of New Orleans,* and after a long and tedious voyage landed at St. Louis on May 3, 1819.

FIG. 16. HENRY SHAW; from a watercolor painting at the Missouri Botanical Garden, by permission of the Director.

He began business on the second floor of a building which he found for rent, and for a time lived, cooked and sold his small stock of cutlery in this one room. The capital with which he bought his first stock of goods was furnished by his uncle. While Mr. Shaw's main object at this time was to make money, and while he denied himself many youthful enjoyments, he still did not thus deny himself beyond reasonable limits.

He had been succeeding in business, and when the balance sheet for 1839 was struck it showed to his own great surprise a net gain for the year of $25,000. His figures were gone over again and again until there could be no doubt of the fact. It seemed to him that "this was more money than any man in my circumstances ought to make in a single year." Accordingly, the following year, when opportunity offered, he closed out his business. At this time he was forty years of age, physically and mentally unimpaired, and vigorous, a free man, and the possessor of $250,000, equivalent to more than $1,000,000 at the present time.

In September 1840, Mr. Shaw made his first visit to Europe, stopping on his way at Rochester, New York, where his parents and sisters resided. He took an extended tour on the continent and, returning to St. Louis in the autumn of 1842, arranged his affairs for another absence in Europe. This lasted for about three years, during which time he visited all of the accessible European localities, together with Constantinople and Egypt. A journey to Palestine was prevented by the prevalence of the plague in that country.

Early in 1851 his last trip abroad was made, the first World's Fair being then held in London. While on this visit the idea first occurred to him to make a garden of his own, modeled after those which are so well known upon the great private estates of England. Mr. Shaw returned in December, 1851; the mansion at Tower Grove had been finished in 1849, and the one on the corner of Seventh and Locust streets was then being built. After this time he was in St. Louis, with the exception of short summer vacations at the Atlantic coast or the northern lakes. Seemingly a man of leisure, he was really a very busy man for the next thirty years, and was never an idler until compelled to be.

In 1857 the late Dr. Engelmann, who was then in Europe, was commissioned by Mr. Shaw to examine botanical gardens and to obtain such suggestions as he might think of value. About this time a correspondence was begun with Sir William J. Hooker, Director of Kew Gardens, who wrote on August 10, 1857:

> Very few appendages to a garden of this kind are of more importance for instruction than a library and economic museum, and these gradually increase like a rolling snowball.

Accordingly, Mr. Shaw in 1858–9 erected a building for this purpose. The selection of books was entrusted largely to Dr. Engelmann in consultation with Hooker, Decaisne, Alexander Braun and others of his botanical friends. At the same time Dr. Engelmann urged upon Mr. Shaw the purchase of the herbarium of the recently deceased Professor Bernhardi, of Erfurth, Germany, which was offered at a very small price. Hooker wrote January 1, 1858:

> He [Engelmann] tells me of the herbarium of the late Dr. Bernhardi, of Erfurth, which he expects to buy for St. Louis. That ought to be a good commencement for the more scientific part of the establishment. . . . The state ought to feel that it owes you much for so much public spirit, and so well directed.

Mr. Shaw has told that he at one time planned a grand school of botany, with residences for the faculty, laboratories, etc., opposite the main gate; but he abandoned the project because of the advice of Dr. Asa Gray.

In 1866 Mr. Shaw secured the services of Mr. James Gurney from the Royal Botanical Gardens of London, whose practical experience and

faithfulness contributed very largely to make the Garden and Tower Grove Park what they are to-day. Mr. Shaw, however, never abandoned his personal supervision, and he thus spent the last twenty-five years of his life perfecting what he had begun. Until the summer of 1885 he had not been out of St. Louis, except to drive out to dine with a friend, for about twenty years. At this time the hot weather caused a failure of his usual good health, and he went to northern Illinois and Wisconsin for some time. He returned much improved and resumed his accustomed avocations with renewed vigor.

On the twenty-fourth of July, 1889, he received numerous visitors who congratulated him upon the beginning of his ninetieth year. Although weak, he was able to meet them in the drawing-room, and his mind was as clear as ever. This, however, was his last public appearance. An attack of malaria resulted in his death on August 25. On Saturday, August 31, he was laid to rest in the mausoleum which had been already prepared in the midst of the garden which he had created —not only for himself, but for all succeeding generations.

FIG. 17. MR. GEO. W. LETTERMAN.

Mr. G. W. Letterman is one of the few persons who have worked upon botany in the vicinity of St. Louis during their whole lifetime. Mr. Letterman has worked especially in Missouri, but is also very familiar with the plants of the region included in eastern and northern Texas, Louisiana, Arkansas and Indian Territory. He has accumulated a very large herbarium, in which the flora of St. Louis is represented probably better than in any other private herbarium.

George Washington Letterman,[23] the son of John and Charlotte (Blair) Letterman, was born near Bellefonte, Center County, Pennsylvania, of a family which had lived for three generations in Pennsylvania, his father being of Dutch, and his mother of Irish descent. From the public school he entered the State College in Center County, but left before graduation to join the Union Army, in which he enlisted as a private; serving until the end of the war he was mustered out of the service with the rank of captain of volunteers. After crossing the plains to New Mexico in 1866, he returned to Pennsylvania, and then going west again to Kansas, with the idea of becoming a farmer in that state, he finally, in 1869, settled in Allenton, Missouri, a railroad hamlet about

[23] Sargent, C. S., "Silva of North America," 13: 79–80, 1902.

thirty miles west of St. Louis. Here Mr. Letterman taught in the public schools uninterruptedly for twenty years, and then for two years served as superintendent of schools in St. Louis County. Shortly after settling in Allenton Mr. Letterman met August Fendler, the botanist, who had a farm at this time in the neighborhood. This meeting with Fendler stimulated his interest in plants, especially in trees, and led to an acquaintance with Dr. Engelmann, for whom Letterman made large collections of plants in the neighborhood of Allenton, with many notes on the oaks and hickories. In 1880 he was appointed a special agent of the Census Department of the United States, to collect information about the trees and forests of Missouri, Arkansas, western Louisiana and eastern Texas, and later he was employed as an agent of the American Museum of Natural History in New York, to collect specimens of the trees of the same region for the Jesup collection of North American woods. The distribution of the trees of this region before Mr. Letterman's travels was little known, and much useful information concerning them was first gathered by him. Of his numerous discoveries species of *Vernonia, Poa* and *Stipa* commemorate the name of Letterman.

The above account is taken verbatim from Sargent's "Silva of North America," as it is the only authentic account of Mr. Letterman's life available. Mr. Letterman still lives at Allenton, Missouri, and is carrying on his botanical work. From the accounts of those in a position to know, his herbarium is very large, and at the present time probably contains as complete a representation of the St. Louis flora as any other, with the possible exception of the Eggert collection, which, however, can hardly surpass it. Mr. Letterman is connected with the local botanical societies, and is well known by the botanical workers of the city.

One man who has left an enduring impression upon botany, although his life work was along other lines, was Dr. Charles Valentine Riley.[23] Dr. Riley was born at Chelsea, London, September 18, 1843. His boyhood was spent at Walton-on-Thames, where he became acquainted with W. C. Hewitson, the author of a work on butterflies. This acquaintance undoubtedly turned his inclinations towards entomology. He studied for three years in the school at Dieppe and afterwards at Bonn. His teacher at the latter place urged him to study art at Paris, but this was not done. At the age of seventeen he emigrated to Illinois and when about twenty-one went to Chicago as reporter and editor for the *Prairie Farmer*. He was for six months in an Illinois regiment during the latter part of the Rebellion. He attained such success as an entomologist that he was made State Entomologist for Missouri in 1868, and he held this office until 1877, when he went to Washington in the government service. During this period he and his assistants, Miss Mary E. Murtfeldt and Mr. Otto Lugger, worked out two cases of the relation of insects to plants which are of more than ordinary interest.

In 1863 there were first noted in France the ravages of the Ameri-

[23] Howard, L. O., *Proc. Soc. Prom. Agric. Sci.*, 17: 108–112, 1896.

can *Phylloxera* upon the tender European varieties of grapes. These injuries became so serious that in 1872 the trouble was known not only in France, but in Portugal, Switzerland, Germany and England, and the entire grape and wine industry of Europe was threatened with annihilation. Riley became much interested in the problem of controlling the pest and finally hit upon the plan of grafting the susceptible European varieties upon roots of the resistant American species. This simple expedient undoubtedly saved the grape industry of Europe and also incidentally prevented a tremendous loss of money.

The second case was one of purely scientific value and interest. Dr. George Engelmann had noted that the character of the pollen of *Yucca* indicated that pollination of the flowers must be accomplished by some kind of an insect. Riley took up this hint and finally, with the aid of his assistants, discovered that the pollination was actually performed by the *Pronuba* and *Prodoxus* moths. This line of work was continued for twenty years, and a series of publications upon it issued at various times during this period.

Incidentally his work was of interest to botanists in many other cases, but these two seem especially noteworthy. He won an enviable reputation among entomologists the world over. He died the latter part of the year 1895.

Because of her botanical work, as well as her association with Dr. Riley in working out the pollination of *Yucca* and other problems, Miss Mary E. Murtfeldt deserves mention. In 1885 Professor S. M. Tracy, then of Columbia, Missouri, published a list[24] of the plants of the state. In this list one finds many species from the vicinity of St. Louis credited to "Murtfeldt" as their collector. These specimens were collected by Miss Murtfeldt not long before the publication of the "Tracy" list and are still in her possession, forming a collection of about 500 numbers. Miss Murtfeldt's first scientific work was in botanical lines, but this later changed to entomology, her botanical knowledge being indispensable in following out the life histories of new or little known insects upon their host plants. Many of her later botanical specimens are of much interest from the entomological standpoint and were prepared for that purpose alone. Miss Murtfeldt is well known among entomologists for her work, which has been mostly of this nature.

In 1874 Mr. Henry Eggert, as he was known, came to St. Louis, went into business, and began the study of the local flora and the formation of an herbarium which probably represented the flora of that vicinity at the time of his death, the best of any in existence. Eggert came to America from Prussia when about thirty years of age; he had already collected and studied the plants of different sections in Europe,

[24] Tracy, S. M., "Flora of Missouri," *Mo. State Hort. Soc. Report* (Appendix), 1–106, 1885.

and his work about St. Louis seems to have been simply a continuation along similar lines to that already done in Europe. Although he lived in St. Louis and in later years in East St. Louis, he seems to have been somewhat of a hermit, and was not understood, or even comparatively well known, by his neighbors. He seems to have been an enthusiast upon botany, and his botanical collection was apparently his one luxury and hobby.

Heinrich Karl Daniel Eggert[25] was born March 3, 1841, in the town of Osterwieck, Prussia. He was educated at a seminary in Halberstadt, and became a teacher in the public schools of the neighboring

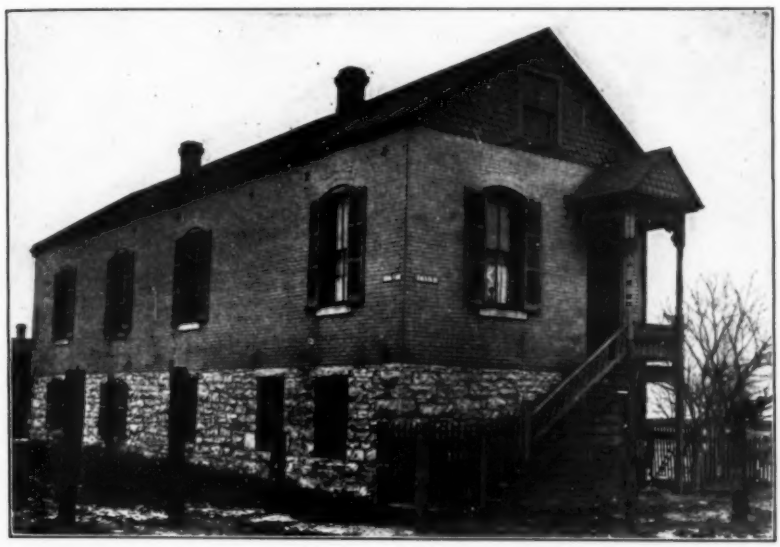


FIG. 18. THE EGGERT HOUSE IN EAST ST. LOUIS, ILLINOIS; practically as it was at the time of the death of Henry Eggert.

city of Magdeburg. He early became interested in the study of plants, and before leaving Europe he had made botanical collections in the Harz Mountains and on short journeys to Kreuznach and in Bohemia. Dissatisfied with the small salary of a German school teacher, Eggert came to America in 1873, and for a few months worked on a farm in southern New York. From New York he went to St. Louis, where he remained for a number of years and then removed across the river to East St. Louis, where he lived the rest of his lifetime.

The first work which he seems to have taken up in St. Louis was that of carrying papers for the local press. He carried papers for about twenty years, handling both a morning and an evening one. He worked early and late, never sparing himself and always living by himself in a secluded manner. Comparatively few persons ever saw the in-

[25] Sargent, C. S., "Silva of North America," 13: 51–52, 1902.

terior of his house, and still fewer were on really friendly terms with him, as we ordinarily use that phrase. While he had but little to do with his neighbors he never seems to have had any enemies.

Eggert's first start in making more money than usual was at the time of the great outbreak of the American *Phylloxera* in the vineyards of Europe, destroying immense numbers of the vines and threatening the entire wine and grape industry of Europe. It was finally discovered that the American native grapes might be used as stocks upon which to graft the more susceptible European varieties, so that a vine was obtained which had roots of the American resistant species with the top of some desirable but susceptible European species. This work resulted in an immense demand for the seed of some of our native species of grapes. Eggert's knowledge of botany led to his being recommended as a suitable person from whom to get these seeds. For at least two or three years he made a business of collecting and selling them to foreign countries. The business was quite remunerative and in the proper season he is said to have made several hundred dollars a month in this way. He seems to have kept up his carrying of papers at the same time. At first he carried them on his back, taking immense loads in a bag slung over his shoulder. As his business grew he bought a horse and wagon and still later he employed others, so that at one time he conducted a considerable business of this kind. He never relinquished his botanical work, and in early days he collected specimens for sale to botanists and for use in colleges and schools, thus making some little money. In later years his left arm and hand became affected with a partial paralysis which he attributed to his severe work in carrying such heavy weights of papers slung over that shoulder.

His money he invested in farms and similar property, and he succeeded in amassing considerable property. In his personal habits he was always very frugal, his only luxury seeming to have been his botanical collecting. In 1896 he sent to Germany for his nephew, August Eggert, and turned his greenhouses over to him to run. This nephew lived more or less intimately with him. Mr. Eggert was always of a peculiar disposition, apparently being constantly in fear of some attempt upon his life. He had hallucinations in which he thought every one had designs upon his life, and these became worse as he grew older. His mind was undoubtedly unbalanced, and on the night of April 18, 1904, he shot himself with a revolver.

As mentioned above, Eggert early learned botany and collected extensively all of his life. He collected assiduously all around St. Louis for a considerable distance, and his collection probably represented the flora of this district better and more completely than any other ever made. He also went on collecting trips to various parts of Missouri, Illinois, Arkansas, Alabama, Tennessee and Texas, and the southeastern states. He seemed to possess a genuine love for botany, and his

determinations seem to have been, as a rule, correct beyond the ordinary. He was a charter member of the Engelmann Botanical Club, and was its first vice-president. He was also a member of the International Association of Botanists, and was made one of its vice-presidents.

Personallly, he seems to have had no enemies; he always remembered an injury, either real or fancied, and was unstinting in his expression of dislike for those who had in any way incurred his displeasure. His love of botany and his fine herbarium made him well known to the local botanists, yet he never seems to have been on really intimate terms with many of them. He was always ready to exchange specimens of rare plants or local species, and his herbarium was thus greatly enlarged by exchange from other countries as well as from all parts of the United States. During early days he collected specimens for the purpose of selling them, but as he grew older he could rarely be induced to sell his specimens, preferring to exchange.

His herbarium at his death was estimated to contain about 60,000 specimens, and was considered very valuable. It was acquired by the Missouri Botanical Garden, and is at present being incorporated with the herbarium of that institution as rapidly as possible. His herbarium is especially valuable for the reason that it was the basis of a local flora published by Eggert in 1891 under the title "Catalogue of the Phænogamous and Vascular Cryptogamous Plants of the Vicinity of St. Louis, Mo." His preface is characteristic and self-explanatory, so that it may well be given:

> Since[29] the publication of Mr. Geyer's catalogue of the Plants of Illinois and Missouri, about 1842, no other effort has been made to publish a list of plants growing in the vicinity of St. Louis but my own partial lists of species found in former years. I hope my present catalogue of Plants growing in a radius of about 40 miles around St. Louis will be welcome to botanists until a local flora is published.
>
> Since 1874 I have systematically looked over the ground in all directions, so that very few plants will have escaped my observation; but as I could only go out one day at a time, in places too far off from railroads, there still may be found something new. Railroads also will bring new immigrants from other regions when some of our own plants may have vanished, so that it will be a very important matter for later botanists to know what in former years was growing here. This idea mostly led me to have this catalogue printed.
>
> With the exception of a few plants reported to me by Mr. Letterman, of Allenton, Mo., all plants are collected by myself. The catalogue contains nearly 1,100 different species and varieties, so that St. Louis need not be ashamed of her flora.

This catalogue of Mr. Eggert's is by far the best and most nearly complete list of our plants which has yet appeared. Besides the above mentioned catalogue, a number of small lists of desiderata were dis-

[29] Eggert, Henry, "Catalogue of the Phænogamous and Vascular Cryptogamous Plants in the Vicinity of St. Louis, Mo.," 1–16, 1891.

tributed to Eggert's correspondents for a number of years. Aside from these he published absolutely nothing, so far as now known. Exact localities were not given either in his lists or upon the labels accompanying his specimens, but he is known to have kept a note-book in which all such data were given. This note-book disappeared during the changes following his death, and thus much valuable and intimate knowledge of our flora was lost. As mentioned above, his entire herbarium is now in the possession of the Missouri Botanical Garden, where it will receive the best of care and will be accessible to all botanists desiring to use it.

One of the more recent collectors who have worked in and about St. Louis, especially upon the fleshy fungi, is Dr. N. M. Glatfelter.

Dr. Noah M. Glatfelter was born in York County, Pennsylvania, on November 28, 1837. He lived on a farm until he was seventeen years of age, when he began teaching school. He finished seven terms, and during the time attended successively the York County Academy, Lancaster County Normal School, and Franklin and Marshall College at Lancaster, Pa., for two thirds of the sophomore year. He then commenced the study of medicine with Dr. John L. Atlee, of Lancaster. In 1862 he attended the medical lectures at the University of Pennsylvania, and graduated from the same institution in 1864. He then received a commission from President Lincoln as Assistant Surgeon of United States Volunteers. In 1867 he left the army in Dakota territory. Ever since that time he has practised medicine in and near St. Louis.

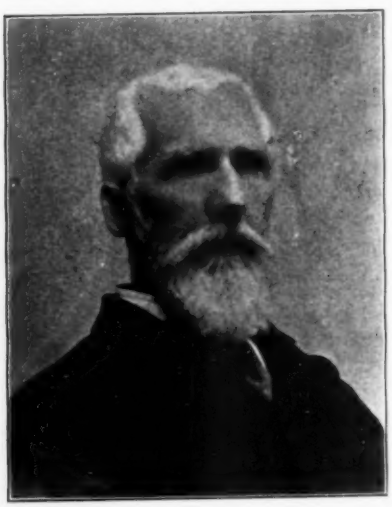


FIG. 19. DR. N. M. GLATFELTER; about 1900.

About 1889 Dr. Glatfelter commenced collecting the herbaceous plants in the vicinity of St. Louis and obtained specimens of most of the species of the district. This herbarium is still in the collector's possession. From 1892 to 1898 he gave special attention to the willows of St. Louis, and contributed papers on the venation of *Salix*, on *Salix* hybrids, on *Salix longipes* and on the relations between *Salix nigra* and *S. amygdaloides*.

In 1898 he became interested in the collection and study of the Hymenomycetes. This has led to the accumulation of about five hundred species, making quite an exhaustive collection of these fungi. This work is being continued and has already resulted in the discovery

of a number of species new to science, several of which have been named in honor of their discoverer. This material has been submitted to Professor Chas. H. Peck, so it is authoritatively named.

In 1906 a list of this collection was published by the St. Louis Academy of Science.[27] The specimens are mostly in Dr. Glatfelter's private herbarium. Collecting has also been done in Pennsylvania in 1899, 1905 and 1906, and somewhat in other states. The herbaceous herbarium has been increased by exchanges, so that it numbers over 4,000 species. Dr. Glatfelter is a member of the local botanical societies and is still collecting the fleshy fungi, to which he is giving most of his attention.

The more recent botanical workers of St. Louis we find grouped into two distinct bodies; the staff of the Shaw School of Botany, and of the Missouri Botanical Garden, and the investigators of the Mississippi Valley Laboratory of the United States Department of Agriculture. In the former group, which has existed for the longer time, the following persons should be mentioned: Dr. William Trelease, director of the Missouri Botanical Garden since the death of Mr. Shaw, and also professor of botany in the Shaw School of Botany. Besides administering the affairs of these two institutions, and bringing them to their present development and efficiency, he has published many scientific papers; the earliest ones were concerned with fungi and various plant diseases; then the pollination of flowers was taken up; and of late years his work has been in the systematic revision of certain groups, such as the genera *Acer, Rumex, Yucca*, etc. Under his management the botanical garden has issued eighteen annual reports of scientific material, which have given that institution a name for scientific research, although it can hardly even yet be said to have fairly emerged from the preparatory stage of its development. Associated very closely with Doctor Trelease since 1894 is Mr. H. C. Irish, who has had general charge of the grounds, greenhouses and outdoor planting. Mr. Irish has published papers on horticultural subjects, including a scientific revision of the genus *Capsicum*, and of the "garden bean," and has in preparation another extensive paper along similar lines. Mr. C. H. Thompson has been connected with the garden for a number of years, and is engaged also upon scientific investigations. Dr. J. A. Harris, librarian of the garden, has published a number of scientific papers, and is engaged upon others, in the preparation of which the extensive and excellent library facilities of the garden are being fully employed. Others who have been connected with the garden staff, and who are now well known scientifically, are Dr. L. H. Pammel, Dr. H. J. Webber and

[27] Glatfelter, N. M., "Preliminary List of Higher Fungi Collected in the Vicinity of St. Louis, Mo., from 1898 to 1905," *Trans. Acad. Sci. St. Louis*, 16: 33–94, 1906.

J. B. S. Norton, all of whom worked more or less upon the fungi of the locality while at the garden. Dr. S. M. Coulter, assistant professor of botany in the Shaw School of Botany, has, ever since coming to St. Louis, been working upon ecological problems.

The second group of botanists is a small one, of whom the following have been more or less intimately connected with the local work being carried upon the flora of the vicinity: Dr. Hermann von Schrenk, in charge of the Mississippi Valley Laboratory until its removal to Washington in 1907, has published a number of scientific papers dealing with the diseases of forest trees and of timber. Some of these were worked out from material collected around St. Louis, either partially or entirely. Dr. von Schrenk continues his work at St. Louis, having severed his relations with the United States Department of Agriculture upon the removal of the Mississippi Valley Laboratory from St. Louis to Washington. Drs. G. G. Hedgcock and Perley Spaulding, assistants of Dr. von Schrenk, were also engaged upon problems relating to the diseases of fruit and forest trees. All three have collected the fungi of the vicinity, and have been intimately connected with the botanical activities of the place.

Besides the above workers should be mentioned Mr. John Kellogg, long employed by the garden, who is very familiar with the local flora, and has a very good private herbarium; Dr. N. L. T. Nelson, who is collecting the mosses of the vicinity; Mr. H. M. T. Hus, who is collecting the algæ; and numbers of others who have collected in the locality at various times.

FIRE'S HAVOC A SENSELESS WASTE

By F. W. FITZPATRICK
WASHINGTON, D. C.

WE have reason to be proud of the phenomenal growth of our American cities, the beauty of their buildings and the vast volume of building construction that is yearly carried on in the process of that growth. But a careful analysis shows us that that great volume of building is not *all* growth, but is, to a very great extent indeed, the replacing of buildings that have been destroyed by fire. And that destruction, a most senseless and cruel waste, has had a proportionate increase, year by year, far in excess of the pro rata of our new buildings or indeed of many other details of our rapid growth. In this country we deal in big figures and it would almost seem as if we were as proud of our appalling wastes as we are of our mammoth productions. At least one would judge so by the complacency with which we contemplate a drain upon our resources that would be deemed positively intolerable in any other country.

Statistics from all over the world for the year 1908 are now pretty nearly complete. Let us see what that year has meant in this fire matter. In the forty leading cities new buildings and repairs to old ones, building construction, reached a total value of $478,000,000 in that year, or a grand total in all the cities and towns of $510,000,000 —the biggest year we ever had in our history, 1905–6 showed a total of $667,000,000. Now then, during the same period we permitted to be destroyed by fire buildings and contents to the value of $218,000,000. Incidentally, the reader will please remember that in most transactions where "losses" occur, those losses resolve themselves generally into transmutations or exchanges. In financial matters where one man loses the other gains, in more scientific affairs fuel, for instance, is consumed but produces steam, power. They say that nothing is utterly lost, but we also know that in this fire proposition nothing is left but ashes and smoke. It is not an exchange. The destruction of value is absolute for so far we have exceedingly little use for ashes, and smoke has not yet been turned into anything commercially or scientifically valuable. Add to the value of property destroyed the cost of maintaining fire departments, fire-fighting apparatus, high water pressure, city and private efforts at *stopping* fire when once it has started, something like $300,000,000. Then, in a further effort to recoup ourselves after fire has laid waste our property, we have gambled with the in-

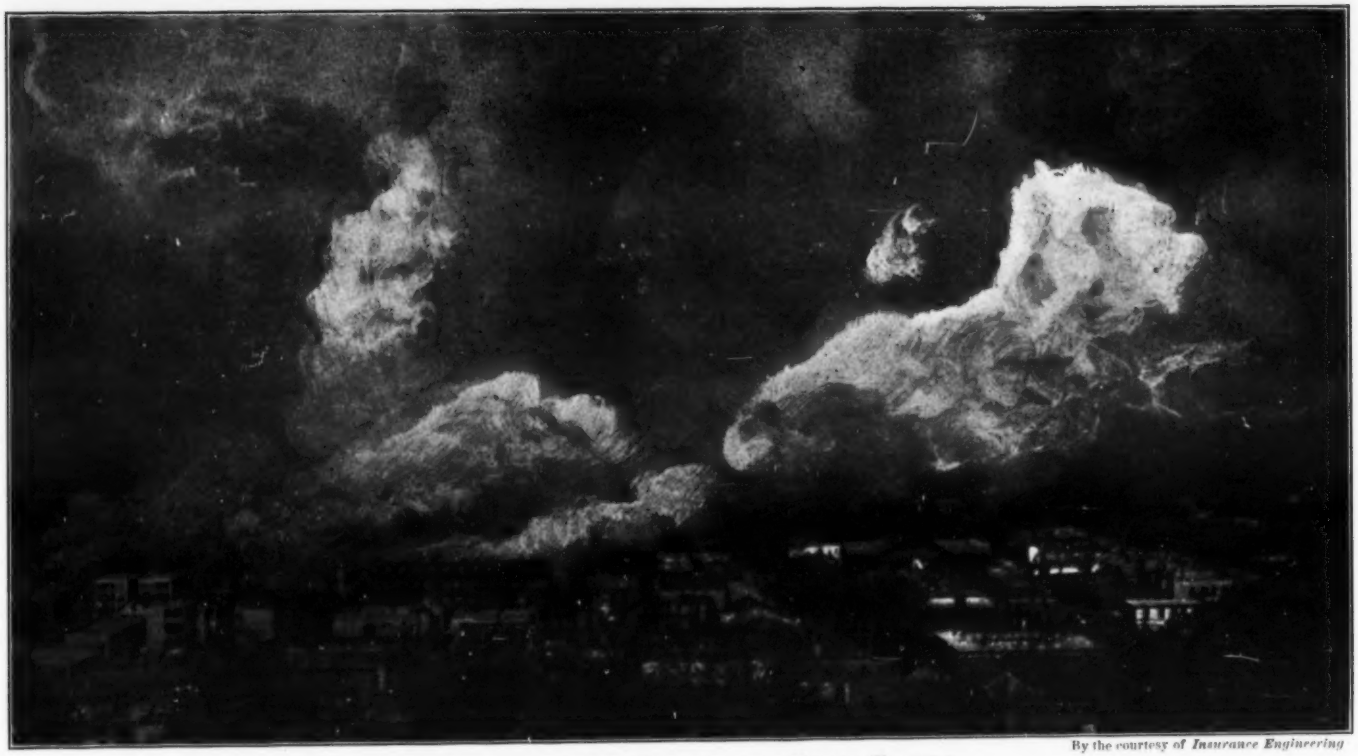
FIGHTING FIRE WITH DYNAMITE AT SAN FRANCISCO.

surance companies in a bet that our buildings would burn. During the year we have paid those companies in fire-insurance premiums $316,000,000. They have paid us back in adjusted losses $135,000,000, so that the difference between those two sums, $181,000,000, is the amount we have paid those companies for the privilege of getting back a little over half of the value of the property we have permitted to be destroyed by fire. Applying the paid losses of $135,000,000 on the burned value of $218,000,000, the net loss in property value was $83,000,000, the cost of fire "protection" of all kinds was $300,000,000 and the amount we gave the insurance companies to guarantee us some

BUILDING THE FLOORS AND PROTECTING THE STEELWORK WITH HOLLOW FIREPROOFING TILE IN A MODERN SKYSCRAPER.

reimbursement for our losses was $181,000,000, so that the total of destroyed values and incidental costs of fire for the year was $564,000,000. Compare this figure that we might call destruction with the new buildings added, $510,000,000, or what we might call production, and the result is not one of which we have any reason to be proud.

Eliminating the consideration of the cost of fire-fighting, we have destroyed in property values $1,258,000,000 worth in the past five years! Again eliminating all incidental expenses fire alone has cost us in 1908, $2.72 per capita. Compare that to the fire losses in European countries and you will realize how far behind them we are in fire-prevention. In France, Germany, Italy, Switzerland, Austria and



By the courtesy of *Insurance Engineering*

VIEW OF THE CHELSEA FIRE FROM THE MARINE HOSPITAL.

Denmark the general average is a trifle less than 33 cents per capita. In Italy it is as low as 12 cents and in Germany it has never been above 49 cents. In thirty of the principal foreign cities the average was 51 cents, while in 252 of our cities the average was $3.10! In New York City in 1908 there were 14,000 fires and the property loss amounted to $7,250,000, and the cost of maintaining the city fire department was $7,000,000; in St. Louis, there were 3,200 fires with a loss of $1,298,000, and the cost of the fire department was $1,018,000, and so our cities run with a general average of the cost of fire departments almost equalling the actual combustion of property. In Europe, Rome may be taken as a fair example, an average. There fire losses amounted to $56,000 in a year in 270 fires and the maintenance of its 200 firemen costs $50,000 and Rome is a city of 500,000 people, or nearly the size of St. Louis.

Let me add just one more comparison and then we will leave tabulations alone, for statistics are always more or less wearying. In this country in January of 1908 the total amount of building and repairs done scarcely reached $16,000,000; during that same month fire destroyed $24,000,000 worth of property.

Surely we have had figures enough to clearly establish and to firmly impress even the layman that fire can be said literally "to be eating at the very vitals" of our economic structure. Many causes have contributed to this deplorable condition. One is that our people are naturally reckless and careless and build as they do much else, merely for the moment, temporarily. Then, too, until very recently our lumber supply has seemed inexhaustible and it was the material with which buildings could be erected with greatest rapidity and least initial cost. The pioneer couldn't be expected to haul brick and steel into the wilderness when he had trees all about him from which he could fashion his rude habitation. Pioneer settlements grew into villages and the villages into cities and the habit of building of wood stuck to them. Why, even last year, with the price of lumber a hundred per cent. higher than it was ten years ago and with incombustible materials available everywhere and at low cost we still built 61 per cent. of the year's construction of wood. In the older communities, in Europe, they have got well over their pioneerdom and lumber has never been so plentiful as with us and the authorities have had more forethought and realized the necessity of better construction so that the general average of the buildings in cities, towns and villages is infinitely less inflammable than is the average here. But from that it must not be deduced that the science of building is carried to greater perfection there than here. That seems an anomalous condition but it's a fact nevertheless that our architects and engineers know a great deal more about fire-proof construction and practise it to a far higher degree of perfection than do

the architects and engineers of Europe. They really have nothing to compare with our superior buildings. Take, for instance, the Singer Tower in New York and regardless of its height, there is nothing in Europe to compare with it in the way of fire-resisting qualities. The trouble with us is that there are so few of those buildings. We have something like 12,000,000 structures in the country, but of that vast number there are but 8,000 in which even the slightest effort has been made at fire-prevention! It is our average construction that is so poor and that makes such a bad showing compared with Europe. You can readily see that in a city composed of buildings that are not fire-proof, but that are comparatively incombustible, the fire hazard is much less than it is in a city of fire-traps with a few perfect buildings scattered here and there. And, too, in order to resist fire those fire-proof buildings have to be superlatively perfect because there is so much fuel all around them that a fire attack against them is vigorous in the extreme. In the European cities the big and important buildings need not to be so perfectly constructed because the danger of fire from within is always the minimum and the danger of fire from without is not very great on account of the superior general quality of construction. There it is seldom that a fire gets beyond the building in which it originates. Here, in spite of our splendid fire departments—and there are none superior to them, for none have the practise and the experience they have—fires frequently extend to neighboring buildings, entire blocks and indeed whole sections of cities.

Municipalities, states and even the country at large are beginning to realize the gravity of this fire waste and that something drastic has to be done towards fire-prevention. The great trouble is that whatever we may do now can simply be an abstaining from adding fresh fuel to burn because we have received such a heritage of combustible buildings that it will be yet many years before those old fire-traps will have all been destroyed or torn down to be replaced with better buildings. But a beginning has to be made some time and most of our cities have so revamped their building regulations that at least within certain districts nothing of an inflammable nature may not be erected. But that is not enough, because immediately outside of those districts we are permitting fire-trap construction that, in turn, will be the inheritance of our successors and will be in congested districts and prove almost insuperable barriers to real progress. The thing to do is to absolutely prohibit inflammable construction, the use of wood, in the structural parts of buildings erected *anywhere* within the jurisdiction of a city.

Many may deem this a great hardship upon the poor man and that it would be almost prohibitive in cost. That is a most popular mistake. The first cost of a fire-proof building is but 12 per cent. or 15 per cent. more than that of ordinary construction. But, considering the differ-

ence in repairs, the longevity of the better building and the lessened, if any, insurance that need be carried, inside of four or five years that difference is wiped out and, as a matter of fact, the best construction is an actual economy, for in no case does the interest on the added cost of good construction amount to anything like the insurance premiums, the wear and tear and deterioration of the ordinary or allegedly cheap building. The only man who profits by the so-called ordinary or cheap building is the Buddenseick, the speculative builder whose business it is to put up the flimsiest kind of a contraption, paint it gaudily and sell it at a fat profit to the easily gulled individual who believes in buying ready-made houses.

ARTISTIC BRICKLAYING.
Indestructible by fire; as effective as granite or marble and less costly.

The space assigned me will hardly permit our going very extensively into the minutiæ of fire-proof construction. Suffice it to say that in general terms it means the avoidance of anything combustible. But farther than that it is also well to remember that many materials that are in themselves incombustible, non-inflammable, are most seriously damageable, nevertheless, by flame or great heat. Iron, for instance, can not burn but subjected to heat it will twist and contort and in column form, as an illustration, it will collapse to the utter destruction of whatever it is supporting. So that many materials have in turn to be protected from fire though they will not themselves burn. Many people imagine that stone represents the very epitome of safe and permanent construction, yet all granites, marbles, sand and limestones spall and go to pieces under severe fire tests. My idea of a perfectly fire-proof building, therefore, is one whose exterior walls are of undamageable material, brick and terra-cotta, products that have gone

AN INSUFFICIENTLY PROTECTED STEEL COLUMN AFTER A FIRE.

through intense heat in their process of manufacture. The internal framing, the skeleton, is of steel, thoroughly protected from fire by brick or hollow tile; the partitions and floors are also of tile; the elevators and stairways are enclosed and with automatically closing doors at every story so that each story is a unit by itself, virtually a separate

FIRE'S INGRESS *via* THE WINDOW ROUTE.

building. This is all-important. Fire's tendency is ever upward. Make it impossible for fire to travel from story to story and you have cut down your fire possibilities 90 per cent. And the same thing applies to each story. These should be so partitioned as to form as small

units as possible. Fire can then do damage only in some small space in which it originates. The whole secret of fire-fighting is this isolation, this keeping of fire within the narrowest possible confines, where it can readily be extinguished and by any employee of a building without having to call out the fire department. Further, my perfect building would have all of its exposed windows or narrow alleys and streets wire glazed in metal sash. What is the use of stout brick walls if you provide openings for fire every few feet and offer no greater barrier in those openings than wooden sash and sheet glass? Forty-four per cent. of our entire fire loss is attributable to this lack of proper window protection. In San Francisco, nearly all the loss was traceable to that same cause, because after the earthquake fires only originated in a comparatively few buildings but spread from one to the other via the window route. My interior decorations would be of marble or metal, or even plain plaster tastily ornamented in color, anything rather than the heavy wooden wainscoting, wooden floors, beamed ceilings and all that sort of thing that means just that much well-oiled fuel or rather kindling for a fire. Such is a really fire-proof building. It is a type that has proved its value time and time and again. It is nothing new and untried; it is not a mere theory. The great trouble has been, however, that some one item or other has been neglected in our existing so-called fire-proof buildings. In one, the windows are unprotected, though everything else is well done; in another the elevator wells are open, some one thing that vitiates the whole, for, remember, that like a chain, whose strength is equal only to its weakest link, so is a "fire-proof" building only thoroughly fire-proof if everything about it is properly done. You can not have half-fire-proof or semi-fire-proof. Those are misnomers.

Therefore, it is imperative that our authorities should demand good, incombustible construction. Left to their own volition it would be years before the people would build that way. It has to be made compulsory. The community must legislate for its safety and against the selfish or ignorant interests of the individual. But it may help the individual nevertheless by making it directly advantageous to him to build properly. Supposing even that the regulations do not exact fire-proof construction everywhere, taxes should be so arranged that a maximum rate should be assessed against inferior, highly combustible buildings. It is for their protection that the city has to maintain expensive fire departments and fire-fighting media; were it not for those buildings such expense would be unnecessary. It is nothing but right, consequently, that the owners of those buildings should pay their full pro rata of that charge. The rate upon first-class fire-proof construction should be the very minimum because those buildings require the least of that protection and their owners should not be made to pay as

DAMAGE BY WATER—$1,000 a minute while these three nozzles are being played upon the contents of a warehouse.

SEARCHING FOR THE DEAD AFTER A FIRE.

INEFFECTIVE FIREPROOFING.

much for it as are others. This would be but equitable in the first place and in the second place would encourage men to replace their combustible contraptions with better buildings. Next and immediately necessary the authorities should conspicuously label every building of public or semi-public nature, just as to its class of construction, "fireproof," "ordinary," "dangerous." As it is now, the term "fireproof" is cruelly abused. It is applied where there is not the slightest foundation for its use and is made the means of obtaining tenants and occupants under false pretenses. A man with "dangerous" affixed to his building would have difficulty in renting it and that would be a powerful incentive to him to at least make the building better if he did not absolutely eliminate it and build correctly. Then we should have the same municipal regulations that they have in most European cities relating to "neighboring liability." Here we have a selfish way of taking care of ourselves and letting the other man shift. There they make you responsible for any damage to your neighbors' premises or property that may result from a fire on your premises caused by your or your agents' negligence or carelessness. It makes people wondrously

careful in handling their ashes, waste paper, etc. These neighboring damages are always collectible at law in Europe and the regulation is one of the most effective of fire-preventative measures.

These are not heroic or revolutionary methods and yet, wherever applied, they would work marvels in the way of bettering conditions There is too much apathy in this fire matter and the authorities who know what it really means are fearful of applying the restrictions that are needed because, forsooth, some of these might too nearly touch powerful constituents or friends. We may only hope to attain the desired ends by forcing these authorities to do what is right via the pressure of public opinion. It is passing strange how those things run, but interesting withal to find that in all reforms the masses have to be compelled to do certain things by authority and the authorities have in turn to be compelled to apply these compulsory measures by the weight of public opinion; public opinion in turn is molded, created by printers' ink and I know of no cause that deserves better at the hands of the press than does this one of *fire-prevention*.

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THE SKY-LINE OF NEW YORK CITY.
The highest and best-constructed buildings in the world.

THE WORLD'S ANNUAL METAL CROP

By THEO. F. VAN WAGENEN, E.M.
ZACATECAS, MEXICO

SOME one has characterized the present as the "age of metals." There are at least fifty-nine of these useful substances known to the chemist of to-day, yet if the average well-educated man was asked to name them, it is doubtful if he could enumerate more than a score. In that far distant period called by the archeologists the "dawn of history" (say 8,000 to 10,000 years ago), only four appear to have been recognized, viz., copper, tin, gold and silver. Sometime later, iron, lead and mercury were added to the list. These seven constituted the metallic stock in trade of the ancients, and of the moderns for the first thousand years of the Christian era. In the opinion of most historians, copper, as the metal that is found most abundantly in the native or pure state, was the first to attract the attention of primitive man, and it is likely that tin was recognized very soon thereafter, for the latter, though far from abundant, and never existing naturally in the metallic state, yet occurs under conditions where it would be easily noted by its weight as a substance very different from ordinary stone, and in a chemical combination from which it can be smelted by the simplest of fire processes. Moreover, the greatest tin-producing district in the world lies in a part of the globe that has been inhabited from most ancient times. Both copper and tin are alone too soft to be utilized as weapons or tools, and humanity at a very early period in the progress of civilization learned to produce, by combining the two, that most serviceable alloy we know as "bronze," which can be forged and tempered to a keen edge and point, and which is so resistant to the attacks of air and water that great numbers of the implements made by the ancient smiths are preserved in the museums of the present day. Gold and silver were doubtless recognized as separate entities at a very early date, and their rarity and beauty set them apart at once as suitable measures of the value of other things. It is thought that iron, though the most abundant of all the common metals, did not come into general use until 1500 or 1000 B.C. For a long time lead was regarded as another form of tin. It does not occur in a metallic condition in nature, only one of its ores (cerrusite) is easily smelted, and most of them are associated with ores of antimony, arsenic and zinc, from which it is separable only with considerable skill. Mercury, on the other hand, comes from its ore with much ease, but it was a puzzle

to the ancients, who called it "liquid or live silver" (whence our modern name, quicksilver), and they found but little use for it. Zinc was also one of the mysteries of the olden times. The Greeks and Romans knew of it as a troublesome impurity, often associated with lead ores, and in some way the very desirable alloy now called "brass," which is composed of tin and zinc, was discovered and produced by them to a limited extent, but the metal zinc remained unknown.

Through medieval times practically no progress was made in a knowledge of the metals.. The science of chemistry was unknown, but its precursor, alchemy, flourished. The alchemists recognized many of the natural substances that are now known as ores of the metals, but were unable, except by accident, to decompose them. However, about the year 1450, antimony and bismuth became articles of commerce, and in 1520 pure zinc was produced, though it did not come on the market in any quantity until 1743. In 1694 arsenic was isolated and recognized. Thus, up to a little more than 200 years ago, the world knew of but eleven of the metals, and of these, arsenic and antimony are not now regarded as such, being classed as semi-metals.

Chemistry, as a science, began to arise during the eighteenth century, as a result mainly of the perfection of the laboratory balance to a point where delicate operations in weighing could be carried on. In this period the list of the metals was doubled by the discovery of cobalt and platinum in 1735–6, of nickel in 1751, of manganese in 1774, of tungsten and molybdenum in 1781, of titanium, uranium and zirconium in 1789, and of chromium and yttrium in 1792. All of these except zirconium and yttrium are now fairly familiar names to us, but none of them were produced in any quantity, or put to any commercial use as metals, for a long time after their discovery. Platinum for a century was merely a curiosity. Certain compounds of cobalt and of uranium found considerable use in the ceramic arts, and of chromium and manganese in the laboratory as reagents, in the crude chemical research of the day. But with the opening of the ninteenth century, and the advance of chemistry to the condition of an exact science, the metal elements began to come to light. Cerium, iridium, osmium, palladium, rhodium and tantalum became known in 1804; in 1807 potassium and sodium were recognized; in 1808 barium, calcium, magnesium and strontium, and in 1817 cadmium and lithium. Between 1828–1830 aluminum, glucium, thorium and vanadium were added to the list, and in 1839 lanthanum. Then came didymium, erbium, terbium, columbium and ruthenium in the five years between 1842 and 1846. In the sixties cæsium, indium, rubidium and thallium were discovered; in the seventies gallium; in the eighties germanium, and since then the chemists have added gadolineum, scandium, samarium, thulium, ytterbium, and finally radium.

The most of these are as yet merely names to the general public, and some are certain to remain no more than chemical curiosities for years to come. There are good reasons to believe, moreover, that the list is still incomplete. But of the fifty-nine now known, eleven, aluminum, copper, gold, iron, lead, nickel, mercury, platinum, silver, tin and zinc, are, as metals, among the staple articles of commerce, which are being produced in large and ever increasing quantities, as the demand grows; while another list of six (manganese, tungsten, molybdenum, titanium, chromium and vanadium) are market staples in the form of alloys with iron, being largely used in the production of certain brands of steel. These are known in the trade as the ferro-metals. Again, there are six more (bismuth, arsenic, cobalt, uranium, thorium and cadmium) that are regularly produced, but not in the metallic state, for use mainly in the ceramic and electrical arts. Finally are iridium, osmium and palladium which find employment to a small but steadily increasing extent among makers of delicate instruments and tools of precision; tantalum, of which the electricians are now making incandescent light filaments, and magnesium, which for a number of years has been used by the photographers in the production of flash light. Thus nearly half of the total list may be said to be already among the indispensables of civilization, and already several of the remainder are under consideration by scientists, engineers and inventors—notably potassium, sodium and calcium—on account of the qualities they possess. Lithium, the featherweight of the metallic family, which will float in water, and has only one fifth the weight of aluminum, may before long be commandeered by the aeronauts, if a way can be found to protect it from the corroding action of air and water, while rubidium, that is as soft as fresh putty or wax at ordinary temperatures, zirconium, that possesses many of the qualities of thorium, and ruthenium, that is extremely infusible, are all certain to fill a want in the arts before long. In fact, each of the remaining known metals appears to possess some inherent and exclusive quality that will sooner or later be needed in our complex civilization. The most of those that are not yet exploited occur apparently in very small quantities in the crust of the earth, as, for instance, the last discovered, radium, which is so rare that but a few grains can be obtained from many tons of its ore. Yet it is one of the surprising facts of recent years that as soon as one of these rare metals is proved to be of real use to humanity, new sources of supply have quickly been found. We know little as yet as to the capacity of the wonderful storehouse we live upon. Nature seems to have provided a substance for every conceivable want of mankind, and beyond question, some of these substances that appear now to be useless are merely in reserve for wants not yet developed, while others that apparently are so scarce as to be

of no practicable use, even if they had desirable properties, have only to be searched for, to be found in sufficient quantity for our needs.

Returning to the eleven well-known true metals, viz., aluminum, copper, gold, iron, lead, mercury, nickel, platinum, silver, tin and zinc, wonderful progress has been made during recent years in the matter of their production. Few of us appreciate the extent to which we are absolutely dependent on some of these substances which, a generation ago, were so rare. It is quite impossible now to conceive of a metal-less civilization, or one in which they were so costly as to be practically unavailable for the ordinary affairs and circumstances of life. In the home, the office, the factory and the club they confront us everywhere. Upon the person of a day laborer ordinarily clothed, half of the list will usually be found, while in the home of the average well-to-do citizen every one, except perhaps platinum, will exist in more or less abundance. It will be both interesting and instructive to note just what amounts of these metals have been taken from the crust of the globe during recent years, for the benefit of our modern civilization.

Aluminum

This metal began to appear on the market as a costly curiosity, in 1888, just twenty years ago, commanding a price of $5 per pound, and the total world's output for that year did not exceed 50 tons. By the end of the century, however, the annual production had increased to nearly 5,000 tons, while the price had fallen to $1.50 per pound. Since then there has been a steady increase of output until during 1906 it amounted to about 20,000 tons, while the price had fallen to 35 cents, causing the metal to be available in so many ways and forms that the civilized world would now find very great difficulty in getting along without it. But, remarkable as has been this growth, it is as nothing to what may be expected in the near future. For aluminum is the most abundant of all the metals, existing in such enormous quantity in the crust of the earth, and in deposits so accessible and so easily mined, that it is certain to become, before another century has passed, and as soon as its metallurgy has been perfected, the rival and supplanter of iron. Every clay bank and slate quarry is a high-grade mine of the metal, only we have not yet learned how to extract it cheaply from these ores. Innumerable other rocks and formations contain it in various quantities. A well-known geologist has recently calculated that 8.13 per cent. of the earth's crust is aluminum, against 4.71 per cent. for iron, and less than one tenth of one per cent. for copper. Bulk for bulk, aluminum has one third the weight of iron. In tensile strength it is almost the equivalent of cast iron, though far inferior in that respect to steel. Yet the metallurgists are rapidly learning how to increase its strength by alloying

with it other metals, and when it can be produced at a price not more than two or three times that of iron, it will certainly replace it very extensively. For it is far more ductile and malleable, it melts at half the temperature, and so may be cut or forged into bars, sheets and tubes at much less cost; it is practically unalterable in the air or water, while iron and steel disappear in rust in a very few years, unless very carefully protected by paint or grease or cement. As yet there is but one ore from which the metal can be produced with reasonable economy, the mineral known as bauxite, which has been found at only a few places, and in masses of comparatively small extent. The rate at which the demand for the metal is now growing will result in their exhaustion in a few years. The great metallurgical problem of the day, therefore, is to devise a means for the extraction of aluminum cheaply from its most abundant ore, ordinary clay. This problem is perhaps on the verge of solution. In another decade we are almost certain to see the metal a staple on the markets of the world at not to exceed five to ten cents per pound. When that day arrives a revolution will have occurred in the industries that it is difficult now to apprehend.

Copper

Accurate statistics of the world's output of copper do not go back much further than the year 1879, when the amount was 170,199 tons. But fairly close approximations have been made for many previous years, and from these it appears that in 1856 the production throughout the world was about 47,300 tons. In 1906 it amounted to 786,794 tons. This is a marvelous increase in the case of a metal that is yet used as a coin by more than half the population of the globe. That the annual product now should be nearly seventeen times what it was about half a century ago, while at the same time the price should be less, explains why civilized nations have abandoned its use as a coin and for ornamentation, and indicates that modern man has acquired much greater facility than his immediate ancestors in extracting it from its ores, which are by no means abundant, nor easy to work. Those of us who have reached middle age can easily remember when a copper kettle was almost a family heirloom, to be kept under lock and key when not in actual use, and whose burnished sides and interior were the pride of the housewife. Nor in those days did we refer disrespectfully to pennies and cents as "chicken feed."

Gold and Silver

The story of the two money metals is much the same as that of copper. A half century ago we used to talk of their production in terms of Troy ounces. During the eighties the kilogram (2.2 lbs.) began to be used as a more convenient unit, and now that has become

entirely too small for silver, while many statisticians are using the 2,000-lb. ton for both metals. A ton of gold would make a little cube measuring about 14½ inches along its edges, and of silver, one of 17¼ inches. Measure these off on your desk ruler and it will become apparent into what small packages nature can pack her valuables if she has a mind to, for the golden cube will represent $602,861.22, while that of silver, at the price of 55 cents per ounce, will be worth $16,041.30. Now, in 1850, just before California and Australia began to produce the former metal in quantity, the world's annual crop of gold was about 60 tons, which could all be stacked away in a small bank vault, having a floor space four feet square and a height of six and one half feet—a mere closet. But in 1906 the crop amounted to 675 tons, more than ten times as much, and to accommodate it would require a vault of the same height, but with a floor space of twelve by fifteen feet—quite a good-sized room. As to silver, in the fifty-six years that have elapsed since 1850, the world's annual production has grown from about 975 to 6,360 tons. Carefully piled up in cubes this mass of the white metal would nearly fill up a room 100 feet long, 20 feet wide and 10 feet high.

Iron

In iron, the metal which is at the basis of the civilization of the day, the record is, if possible, even more remarkable. Reasonably accurate statistics of the world's production do not go back of the year 1865, when it amounted to 10,009,632 tons. In 1906 the output was 64,983,481 tons, showing an increase of nearly 650 per cent. in the forty years. Such figures are not easily grasped by the mind, but let us make the effort. Metallic iron weighs seven and a half times as much as an equal bulk of water. A cubic foot of water will weigh in round figures 62 pounds, and consequently one of iron will tip the beam at 465 pounds. This means that a ton of metal will contain a little more than four and a quarter cubic feet, and that a cube of it measuring about nineteen and a half inches along its edges will weigh a ton. Hence, the output of the year 1906, if put in the form of a solid cube, would contain 279,429,000 cubic feet, and would measure along its edges nearly 650 feet. A city block in New York measures, say, 250 by 500 feet, and its area is about 125,000 square feet, or roughly, three acres. Ten such blocks would be completely covered to the depth of 220 feet by the world's output of iron during the year 1906. This would be the equivalent in dimensions of an eighteen story building, completely covering a thirty-acre tract of land in the metropolis of America.

But to gain even a more striking impression of what the metal is to modern man, let us figure up the total production of the iron mines of the world during the last eventful forty years. In round numbers,

it amounts to over six hundred million tons. Such a mass will measure up nearly twenty-six billion cubic feet. Put this into the form of a pyramid, with a base ten thousand feet square (about twenty-three hundred acres) and its height would be nearly eight hundred feet. Or, cut down the base to dimensions of a five thousand foot square (say sixty acres) and the structure would be nearly two thirds of a mile high. It may not be so difficult then to agree with the iron producers who claim that another half century of such strenuous civilization as the last one will serve to exhaust all the known great iron deposits of the world. Who of the generation that saw the Civil War would have imagined such an expansion of an industry that was then but lightly regarded even by economists? It is indeed high time for the chemists and metallurgists of the day to redouble their efforts to solve the problem of the cheap production of aluminum, for in that direction only does there seem to be an escape from the dilemma of a world unable to procure the common metal it needs, if its civilization is to continue.

Lead

In the case of lead we come down to more ordinary figures, yet none the less surprising when the services the metal gives us, by reason of its peculiar qualities, are considered. Without lead, no paint, no shot or bullets, no flexible piping. These are the three principal uses to which it is put in these days, and more than half of the annual crop of the mines becomes paint, and is employed to protect and improve the appearance of the structures that man raises to live, and to transact his business in. In 1885 the world turned out 391,542 tons of the metal. Lead is a dense and heavy substance, and it only requires a cube measuring a short seventeen inches along its edges to weigh a ton. Even so, the production of the year 1885 would make a mass covering a quarter of an acre of ground, and standing nearly one hundred and ten feet high. But when the year 1906 closed, and its doings were figured out by the statisticians, it was found that the lead mines of the world had turned out in that twelve months nearly three times as much as they had in 1885. To be accurate, the crop amounted to 1,061,533 tons. This mass of metal would make a pyramid with a base one hundred and fifty feet square, and rising nine hundred feet into the air. An increase of 300 per cent. in twenty years indicates an enormous growth in the demand for paint and putty, to say nothing of the consumption in the way of ammunition and piping.

Mercury

Mercury is the one degenerate in the family of the metals. Between 1850 and 1860 it was tremendously in demand by the miners

of Australia and California, who were gathering their golden harvest with its aid, and in the two succeeding decades the silver miner also impressed it extensively into his service. But as the various great precious-metal mining districts of the world became connected with fuel and labor centers by rail, the smelting industry arose and gradually supplanted most of the amalgamation process in which quicksilver was the prime factor, and so the demand for it slowly declined. The largest recorded yield occurred in the year 1877, when the output amounted to 5,308 tons. In 1906 the world's production was only 3,964 tons. For many years now the silver miner has given up its use almost altogether, but the Alaskan placer miner must still have it, and there is yet a considerable consumption in those gold districts of Africa and Australia, where smelters do not exist, and even in our own west, at isolated or very low grade mines. At present the principal demand is for the manufacture of mirrors, and certain scientific instruments like thermometers and barometers. There is good reason to believe that there yet remains, undiscovered, in Asia, Africa and South America, one or more great gold placer regions. When these come to light the market for mercury will revive, and remain active until the new fields are exhausted. There is no lack of its ores in the crust of the earth. The metal has been produced in Spain for at least three millenniums; the California deposits are far from being exhausted, though they have been worked more energetically in the last fifty or sixty years than the Spanish deposits since their discovery, and the great mines of Huancavelica in Peru have hardly been touched. So when the demand again arises, mother earth is prepared to meet the drafts of her children, as usual.

Nickel

Fifty years ago this metal was practically unknown, except to the scientist. Its successful production as an article of commerce began in the United States about 1863, when it was detected in some copper ore coming from the Lancaster Gap Mine in Pennsylvania. For the next ten years, practically the entire world's output came from this mine. At its best, however, the yield never exceeded 100 tons per year, the metal commanding a price of $2.50 to $3 per pound, which of course severely restricted its use. In 1867 one of its ores was found in comparative abundance in the island of New Caledonia, a French possession, lying to the northeast of Australia, and commercial production from there began about 1874. In 1880 the metal was discovered in copper ores coming from Sudbury district, Canada, on the north shore of Lake Huron, and by 1886, a production began which has since steadily increased until at the present time two thirds of the annual world's crop of the metal comes from the later locality.

Finally, there is a small amount produced annually in Sweden and Norway. The total world's output in 1906 was in the vicinity of 19,000 tons. The largest use to which it is now put is in the manufacture of an alloy with iron which is particularly hard and tough, and hence suitable for armor plate. After that comes nickel coinage and plating. The metal has excellent qualifications for these latter purposes. It will not corrode or blacken under ordinary atmospheric conditions, it takes a high polish, and its soft white luster, with a faint tinge of yellow in it, is exceptionally pleasing to the eye. The modern world has a genuine need of nickel, and so the production will increase, but it is never likely to become as common a metal in the arts as copper or lead or zinc.

Platinum

The heaviest of all the metals is also the rarest of those that have become staple articles of commerce. It required nearly seventy-five years after its discovery for mankind to find uses for it. Then its extreme resistance to heat, and to the action of acids, commended it to the chemist, and later to the electrician. It began to come into the market in small quantities in 1824, from the region where it was first found—the western foothills of the Andes in the republic of Colombia. Almost simultaneously it was found in the Ural Mountains of Russia. The Colombian region has never been exploited or worked regularly, owing to the unsettled political conditions of the country, and it is figured that up to date not over 25 tons altogether of South American origin have been produced, practically all of which was gathered by natives in a desultory way. The Russian field has been operated regularly since its discovery, but with little enterprise or judgment or science. The metal has also been found in small quantities associated with gold in the auriferous gravel deposits of the Pacific coast of our own country. But up to the end of 1907 not more than 160 tons altogether of platinum had been produced throughout the world since its discovery, in spite of its rapidly increasing price, for it is now worth, weight for weight, about 25 per cent. more than gold. It is a real commercial misfortune that the two localities where it exists in such comparative abundance, and from which it could be produced in quantity, are under the control of nationalities so backward in social conditions and general civilization, that capital and engineering talent hesitate to take the risks involved in the illiberal laws and disturbed conditions that prevail. The metal occurs in nature generally in the pure or native state, and in the condition of grains, nuggets and dust disseminated throughout deposits of gravel, from which it is very easily recovered by methods similar to those employed in operating gold-bearing placer mines.

Tin

The story of tin is particularly interesting because it illustrates (perhaps better than that of any other metal) the interdependence of the elements of modern civilization. In 1862, which is about as far back as accurate statistics of its production go, the world's annual output was roughly 22,000 tons, of which about half came from Cornwall, and the balance in small and scattered amounts from Germany, Austria, South America, Mexico and the East Indies. In 1906 the crop amounted to nearly 109,000 tons, showing an advance of almost 500 per cent. in 45 years. When we investigate the uses to which the metal is put, we find that previous to our Civil War about all the need the world had for tin was for the manufacture of cooking and kitchen utensils, and for roofing. Now, however, nine tenths of the demand is caused by the canned food industries, and those connected with the distribution of mineral oils. Tin roofs are completely out of fashion, and aluminum is rapidly becoming the favorite kitchen metal. But the tin can, made of plated sheet iron, is the vehicle in which kerosene has traveled to every part of the inhabited globe, and which has made it possible for the fisherman, the stockman, the farmer and the horticulturist to deliver their products in a fresh and edible condition wherever there are people who want them. It is an interesting fact that quite three quarters of the annual crop of tin now comes from the East Indies, and is gathered by Chinamen and Malays. The region is probably the most ancient mining district in the world. Tin has been coming from there in small quantities for at least 5,000 years, ever since the beginning of the bronze age of the archeologists, and the world is only now beginning to appreciate the extent and value of the field. More than fifty per cent. of this old world product finds its market in the United States, where it is converted into millions of cans of all kinds, from the familiar five-gallon receptacle in which the Standard Oil people pack their product, down to the diminutive sardine can of the picnicker. When these are filled and sealed they start on their travels, and in a few brief months—or years at the outside—the neat vessels are scattered throughout the world from the equator to the poles, over the plains and deserts and through the mountains. Vast numbers of the larger sizes are doing duty as water pails everywhere, while the remainder become vagrants and strays in the refuse piles that everywhere mark the paths or dwelling places of man. Thus the metal, gathered with toil and danger by the patient and stolid oriental, is by the strenuous and impatient occidental put to a use which almost immediately insures its dissimination to and dissipation in every corner of the known world. Without tin, our present-day civilization would almost come to a standstill, and certainly the exploration of the yet unknown parts of the planet would

be seriously delayed. The metal is almost as resistant as gold to the action of air and water, and to the attacks of those acids which exist in foods of all kinds, and which in a few weeks would destroy iron, and convert copper, lead or zinc into poisons, and kindly nature has segregated it in the crust of the earth in places where it may be collected at moderate cost, and utilized in activities that have become quite of the nature of indispensables to the further progress of humanity.

Zinc

This metal, which a thousand years ago was a puzzle to the metallurgists, and a nuisance to the lead miner, has become, during the last quarter of a century, one of the most useful and necessary products of the mine. The demand has increased so enormously that producers have at times had the greatest difficulty in meeting it. We have no reliable statistics of the world's output previous to 1883, when it amounted to 310,000 tons. Its principal use up to that date was for the production of brass, an indispensable alloy in the manufacture of bearings and fittings for all kinds of machinery. Previous to the present mechanical age its only use was in ornamentation. Now many other employments have been found for the metal. In the condition of an oxide it is consumed very extensively by the paint manufacturers. In the form of an electrically deposited coating on sheet iron it is in great demand by the building trade for cornice work, etc., under the name of galvanized iron, and is exported in enormous quantities to all new parts of the world for use as roofing and siding in those temporary structures reared for protection against the weather in lands where lumber is not available at reasonable cost. With the development of the electrical industries it has become a necessity in many forms of batteries, and during the last dozen years or so hundreds of tons have been consumed annually in the recovery of gold from certain of its ores by means of what is known as the cyanide process. These new uses, as well as the steady increase in the demand for brass in the ever-growing machinery trade, have caused its production to grow with such rapidity that in 1906 the crop amounted to 774,525 tons, a gain of 250 per cent. in twenty-four years. Zinc is not reckoned as one of the heavy metals, nor yet is it a light one, its specific gravity being a little less than that of iron. Yet if the product of last year was melted and cast into a pyramid with a base of an acre, the apex would stand at an altitude of about 250 feet. This is a fairly good record for a metal that in 1850 was practically unused except in the form of brass. By itself, it is a beautiful substance, almost as soft as lead, very malleable, and with a rich blue-white luster that is the delight of the artist.

History seems to indicate very clearly that nations who have pos-

sessed and developed notable deposits of the metals, have invariably taken a prominent position among their contemporaries, and have reached a higher physical and intellectual plane than those dependent alone upon agriculture or on commerce. Food crops quickly disappear. Fabric crops are worn out in a year or two. Fuel crops burn up about as quickly as they come into the market. There must be an annual harvest of these or trouble ensues. Commerce is the science of the distribution of crops, and is dependent on them for its existence. The various metal crops, however, are of the nature of permanencies. They go into *use* and not into *consumption,* and a very considerable part of each year's addition to the world's stock become articles or structures that are capable of earning interest for their owners. Probably in this lies the explanation of the prosperity that invariably results from an active metallic production. These substances can not be eaten up like wheat, they can not be worn out like cotton or wool, they can not be burned up like coal or lumber or tobacco. They remain and accumulate, are perhaps remelted and used yet another time, and even such parts as are apparently lost in the chemical arts, or in plating or ornamentation, are very extensively recovered from time to time. As a nation, we are producing about 35 per cent. of the world's crop of aluminum, 58 per cent. of that of copper, 23 per cent. of the gold, 33 per cent. of the lead, 43 per cent. of the iron, 26 per cent. of the mercury, 30 per cent. of the silver, and 29 per cent. of the zinc.[1] This is a remarkable record for a community that has existed for less than a hundred and fifty years, and it means that not only are we in possession of a part of the globe that has great mineral resources, but that our form of government and the nature of our laws are such as to foster and encourage that individualism that alone permits a people to develop the best that is in them. The metal era has but just begun. The earth beneath us is a storehouse abundantly full of them. Heretofore man has been content to utilize only those things that were on the surface of the planet. We have now begun to call upon the earth for its very heart blood. Heretofore the mason and the woodworker have been almost the sole executors of the will of the architect and the artist, but now the founder and the smith are becoming his main interpreters. Substances that can be liquefied and molded, rolled and hammered and drawn into form, are taking the place of those that with painful and long effort must be chiseled and sawn. Materials that seem to be capable of taking on life, that can be made to pulsate and vibrate, that will transport energy and light and sound and other forms of force, are being substituted for inert stone and brick and mortar, wherever strenuous life exists or is to be protected. In its future evolution

[1] Statistics of the year 1906.

mankind is bound to reflect this great change in the nature of the materials upon which it impresses its ideals and will.

On the following sheet is given the statistics of the crop of the principal commercial metals for the year 1906.

THE METAL CROP OF THE WORLD DURING 1906

	Tons	Value
Aluminum	20,157	$15,319,320
Copper	786,794	309,996,839
Gold	675	406,931,323
Iron	64,983,481	2,323,799,280
Lead	1,061,533	120,483,995
Mercury	3,964	4,233,552
Nickel	18,983	16,879,684
Platinum	5.5	3,527,481
Silver	6,365	123,822,928
Tin	108,738	86,577,768
Zinc	774,525	69,428,421
Total	67,765,220.5	$3,481,000,591

SCIENCE AND MORALITY

By Professor ALBERT P. MATHEWS
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ONE of the most striking phenomena of the nineteenth century was the great rise of science and the loosening of religious ties coincident with a marked improvement in general morality. As it has for centuries been generally taught that morals depend upon religion, this phenomenon has to many appeared inexplicable. Indeed, some have closed their eyes to the great change for the better that has taken place,[1] so convinced are they that an improvement of morals is impossible except through religion. To them the basis of morality has seemed to be slipping away with their religious tenets.

The decadence of theology accompanying the rise of science is no mere coincidence. The general enlightenment of the age, which has been brought about by the scientific method, has undermined the Christian theology and indeed all theology in two ways: it has, on the one hand, seriously impaired the authority of the Bible as an errorless book; and, on the other hand, in a far more important way it has revolutionized the world by exalting reason rather than faith. What may be called the scientific habit of mind is incompatible with the blind acceptance of statements unsupported by evidence. Science has been justified, moreover, by the enormous contributions it has made to human happiness in the last half century. The question is, having thus undermined religious beliefs, what has science to offer in the place of religion as basis of morals? Can it take the place of religion as an aid to morals?

The discovery of the fundamental causes of moral conduct is of the first importance if we are to answer these questions and hasten the process of improvement. For it has been generally felt that our progress in national and individual morality is not so rapid as it ought to be. A method of hastening the process is sought and many suggestions have been made, the most frequent being that of teaching morals in the schools. It is obvious that before proceeding intelligently we must understand what the causes of morality are. If morals depend upon religion it would appear sensible to give religious instruction in the schools; if, however, the deep springs of good

[1] By many people the awakening of public consciousness of the immorality of certain acts is misinterpreted as an increase in immorality, instead of the distinct improvement in morals which it actually represents.

conduct have some other source than theology or religion, then religious instruction would not be the remedy sought. Indeed, it is possible that those springs of virtue may be choked and their flow retarded by theological tenets, and the remedy proposed would not only not be beneficial but actually detrimental.

To clear the ground for a discussion of the causes of morality it is first necessary to agree on what moral conduct is. If virtue no longer consists in obeying a set of arbitrary statutes given to man by an omniscient being, what criterion shall be used in judging conduct? What makes lying, murder, adultery, covetousness, immoral, since that they are immoral we all feel instinctively? How can we tell good from bad conduct? The answer is obvious from the results which follow such conduct. All immoral acts result in communal unhappiness; all moral acts in communal happiness. The ten commandments really constitute the "common law" of morality; for, although they have been given the form of mandatory statutes, they actually represent those fundamental principles of conduct which humanity has found by experience to be necessary to human happiness. Humanity should, and does, modify and add to these basic principles as long experience shows to be desirable. We can use this criterion for distinguishing good from bad conduct and say that all acts which cause general unhappiness, or permanently diminish human happiness, are immoral; and all acts which increase it are moral. This criterion enables us to understand why different standards of morality exist among different peoples, since the immorality of any act is not generally acknowledged until the misery which comes from it is generally perceived.

Since moral conduct conduces to general comfort and immoral conduct to discomfort, one factor in the improvement of morals is obvious, for that the general happiness is influenced by the acts of individuals is perceived by all. Humanity has been driven by its own unhappiness to adopt a code of actions which produces a minimum of unhappiness. In other words, it has been driven away from immoral and toward moral conduct. This, however, is not the whole, and possibly not the most important, cause of individual morality. Such an altruistic basis of morality would probably not be a sufficiently powerful incentive to good conduct in each of us, were it not reinforced by another factor. The selfishness of the majority of men is so great that the unhappiness of others, produced by their acts, would have little effect in modifying their conduct, provided their own happiness was secured, were it not for that other factor.

There is in each one of us a fundamental instinct which actually makes the happiness of others the most powerful of all incentives to morality. Man is endowed by nature with a feeling of love for his fellow men, which makes it impossible for him to be happy and at

the same time to conduct himself in an immoral manner. This instinct is the most effective incentive to civilization. It underlies all our material and moral progress; it is the source of most that is good; it is the whip driving us onward and the reward enticing us along the straight and narrow path. It is human affection, the social instinct. It is a feeling, to be sure, differently developed in different races, tribes and individuals, but it is present to some extent in all. It is a feeling which develops as one grows, extending outward from oneself. It is at first for parents, brothers and sisters, then for wife and family; for blood relatives; for tribe or nation; and finally for the race. It is the feeling of kinship. It is one of the strongest basal instincts of humanity.

The real origin of morality in the past has been this basal instinct; and it must continue to be an effective cause of morality in the future. For the love of offspring of which this instinct is part is one of the most fundamental in animals. Religious beliefs may develop or thwart this instinct, but they are powerless either to suppress it entirely or to take its place. If we should take away all religious belief, the belief in a personal God, in a future life, in rewards and punishment in such a life, we should not disturb this fundamental basis of moral conduct in the least degree. The instinct of human affection would still exist as a powerful aid to morals, one which has always existed, which always will exist and which is without any essential connection with any religious belief whatever.

Religion and science have a certain relationship to this fundamental instinct. Religion in certain ways, but unfortunately not in all, has acted as a stimulus to this instinct in each individual, and it has presented a moral code enforced by a system of rewards and punishments. The actual effect of the Christian religion on morals has been both good and bad. The rapid development of this religion at the outset was very largely owing to the fact that it appealed to and stimulated this fundamental instinct. The teachings of Jesus appear for the most part to have been directed chiefly to this end. "This is my commandment, that ye love one another." His whole life was a teaching by precept and example of the blessings of human affection. It is this element which has made the religion live; which is accountable for what good it has done in the world; which makes it unique among religions. The appeal of the religion was primarily to the feelings, but it was just as effective an appeal to the reason, if only one perceived that the real basis of all good conduct was affection.

If the early Christians had contented themselves with following Jesus's teachings in this particular, their religion must always have been a power for good in the world. But it happened that metaphysical speculation gradually wrapt around, concealed and weakened the force

of those teachings. It was taught that Jesus was the son of God himself, miraculously conceived; the doctrine of the Trinity was invented and more stress came to be laid on the value of believing these doctrines than in doing the things Jesus declared to be good. The doctrine of salvation by faith became dominant and with this became associated many other conceptions, the general effect of which was to paralyze the growth of the germ of good contained in the religion. These conceptions divided man from man, race from race; they taught men to value their own salvation more than the happiness of others, and their general effect was selfish and opposed to the feeling of human brotherhood, which Jesus sought in every way to arouse, and which is the basis of morality. So completely did they modify that religion that they made of it for centuries a blight instead of a blessing, detrimental alike to moral, physical and intellectual progress. On the whole, therefore, it must be admitted that the good produced by the Christian religion has not been unmixed with evil.

Since the Christian religion was built on the same foundation as morality, not morals on that religion, and since the effect of the religion was both good and bad we can understand how it happens that the decadence of theology does not involve the decadence of morality, but may coincide with its improvement.

Morals, however, have not only not declined; they have actually improved, owing to a change in that instinct on which morality rests. The past century has seen a tremendous growth in the feelings of human brotherhood; the social instinct has been wonderfully stimulated. This is the most glorious achievement of science.

Science besides its material conquests of nature has developed human pity and compassion. It is the greatest preacher of the brotherhood of man since Jesus. Science, as a matter of fact, is developing in us just those feelings Jesus himself sought to arouse. By teaching man the causes of his own conduct, he is filled with charity and pity; by annihilating distance and time, it has broken down artificial barriers between groups of individuals; and, by the solution of the transportation problem, it has brought distant nations close together. It has shown the human race to be actually one great family, of which the misery of any part necessarily affects the happiness of the whole. The evolutionary hypothesis, the germ theory of disease, the telegraph, the telephone, the locomotive, the printing press, the daily paper, wireless telegraphy, these are the great moral apostles of the age, for they knit men together, conquer prejudice and extend our sympathies. Every discovery in science is a step forward in morality. Science is, indeed, in this way one of the greatest, if not the greatest, moral influence the world has beheld.

But science has done still more for morality than to stimulate

human affection. In another and not less glorious way it has exerted a profound influence for good. It has taught the golden value of truth and candor. Beliefs, dogmas, have no place in science. More than any religion science has inculcated the love of truth for its own sake. Truth, modesty, candor! That is its creed, so far as it has any. So rare; so simple; so powerful for good! Science has patiently taught, at first to a few and now to the multitude, that the understanding of the causes of things can only come through patient and unprejudiced study. A mighty force for good has come into the world unknown to it in all its past history.

Perceiving that virtue springs from affection, it becomes possible intelligently to attack the problem of moral instruction in the schools. It would be a mistake to return to religious instruction as a basis of morality, for, as we have seen, morals do not really depend on religion and there are many tenets of the present faith which are, on the whole, distinctly detrimental or, at least, not an aid to morality. Duty, or responsibility to others, should be the key word of education. While all knowledge is a moral force, knowledge being in its nature essentially moral since it increases happiness, and while any real education is in itself a powerful aid to morality, it would be well indeed if the ideals of science could become the ideals of every one; if the love of truth and candor could permeate every individual; if the interdependence of mankind could be so clearly perceived by all that obscure crimes against the community could be recognized and detested. Above all, the whole plan of education, if it is to be efficient morally, while it stimulates the feelings of sympathy, compassion, duty and affection, must inculcate habits of logical thought, the conception of physical cause and effect, and a knowledge of the work-a-day world. For all morality has in it these three components, reason, knowledge and affection; and affection alone is instinctive and blind.

We need not worry, therefore, over the decadence of religious beliefs. All that is erroneous in such beliefs it is obviously immoral to uphold and should be got rid of as soon as possible. Unproved hypotheses, such, for example, as that of a continued, conscious existence after death, should not be taught as facts. For that man who builds his moral edifice upon such unproved beliefs is assuredly building on a doubtful foundation. What is good and worth saving in religion will be found to be working in the future side by side with science in increasing in each individual that human affection which makes man better, will he nil he, and is the really valuable thing in the characters of all of us.

Moral conduct, then, is conduct which increases human happiness. A man must be moral if he would be happy, since he has in him a fundamental instinct, the social instinct, which causes him to love his

children and his fellow men, and which will not permit him to make them unhappy without making himself unhappy also. This feeling of human affection is the real basis of morals. It does not depend on religious beliefs; it will persist even though all religious belief perishes. It has been greatly stimulated by science and it is on account of the development of science that the world has grown better, while its religious beliefs have weakened. And, furthermore, anything which hinders or opposes the development in each individual and each nation of this feeling is seen to be necessarily immoral. From this point of view all obstacles to free trade, free intercourse and friendly relations between nations and individuals may be shown to have an importance in general morality.

STEPS IN THE EVOLUTION OF RELIGION

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THE most remarkable thing yet discovered about this planet is the fact that human beings exist upon it in large numbers, scattered almost everywhere over its surface, that pay homage to superterrestrial powers. But this fact, remarkable as it is, is only a portion of the truth. For the most searching and unprejudiced investigation has failed to reveal any time in human history when it was otherwise. However ignorant and forlorn man may have been in the past, we have no evidence that he has ever been so low down in the scale of being that he did not look upward with some degree of reverence and awe to higher powers.

Not many years ago this fact of the universal prevalence of religion among men was seriously called in question by no less weighty writers than Sir John Lubbock and Herbert Spencer. They quoted at length from the reports of certain travelers and missionaries among the Eskimos of North Greenland, the Hottentots of South Africa and the Indians of Lower California in support of their position; and they stoutly contended that in these documents we have proof positive that there are communities now in existence that have no religion at all. This challenge led to a careful and thorough study of the status of these tribes by competent anthropologists, and in every case an extensive mythology was discovered among them, together with elaborate religious rites. A false idea of the meaning and scope of religion, a short stay in the country, or a lack of knowledge of the native language, had been the cause of the mistaken judgment. Probably no scholar of repute to-day would hesitate to accept the statement of Professor Brinton in his recent work on "The Religions of Primitive Peoples" that:

> **There has not been a single tribe, no matter how rude, known in history or visited by travelers, which has been shown to be destitute of religion under some form.**

The reason for this historical fact is a psychological one, and has never been more clearly or forcibly expressed than by Dr. Edward Caird. He asserts:

> **Man, by the very constitution of his mind, has three ways of thinking open to him: he can look outwards upon the world around him; he can look inwards upon the self within him; and he can look upwards to the God above him.**

And he very appropriately adds, "none of these possibilities can remain utterly unrealized."

For the fact is that man is a self-conscious being. And inasmuch as he is endowed with some degree of reason and will, he can not stand still and passively gaze at the objects about him as though he were a mere brute. He must at least exert himself enough to form some kind of a conception of the powers around and above him, and put forth some degree of energy to place himself in harmonious relations with them. But it should not at all surprise us if, at the outset of his career as a religious being, he shows the same confusion of ideas about the objects he worships, as he does about all the other matters that come within the sphere of his experience. On the contrary, we should naturally expect to find him growing and developing in his religious ideas as he grows and develops in all others.

As a matter of fact, this is actually the case, and it will be our present purpose to trace out in a general way some of the principal steps that he has taken as he has advanced from lower to higher conceptions on this subject in the course of history.

It is now generally agreed by careful students of anthropology that the most primitive form of all religion is best characterized by the word spiritism. This is the naïve and unreflective belief that most objects in this world, especially those that are capable of motion, contain an unseen being which, for the lack of a better term, we will call a demon, or spirit; that these spirits have superhuman powers and can affect for good or ill everything that concerns the ongoings of nature and the lives and happiness of man. In this stage of development human beings attribute all their pleasant experiences to friendly demons, and all their disagreeable ones to just the opposite source. Hence they make use of every means in their power to win the favor of the good spirits, and ward off the envy and wrath of the bad.

The reason for this state of things it is not hard to find. For when the primitive man first begins to give form to his religion, he is himself the only being that he knows anything about that possesses the power of spontaneous action. He can not help attributing the same power to all the objects with which he in any way comes in contact. He acts just as every little child acts in a similar condition. Any object that constantly gives a baby pleasure it pats and caresses with affection. The one from which it gets a hard pinch or knock it wants to pound and kick with all its power. It spontaneously assigns to the object the same sensations and feelings and will as it is itself conscious of. Its experience is so limited and crude that it does not know enough to do otherwise. So it is with primitive man. To him every other is another, and he attributes to that other all of his own powers. In his opinion the world about and above him is made up of a vague,

indefinite host of superhuman demons or spirits, and the form of his religion is determined by that fact.

Another thing that confirmed the primitive man in the belief that he was surrounded by a world of supersensuous beings was his experience in dreams: when he had developed far enough to remember his dreams with any vividness, he always thought of them as real experiences. The beings that visited him in his sleep were as genuine realities and as truly to be dealt with as any that he came in contact with when awake. In fact, he finds that he can often do things in dreams that he can not do when awake, and that he frequently communes with beings that he has no knowledge of when awake. The Kamchatkans and Eskimos, we are told, determine what they will do when awake to a great extent by their dreams; for they regard the knowledge obtained in this way far superior to that gained through the senses. Lucretius, however, goes too far when he asserts that "the dreams of men peopled the heaven with gods." Many of the lower animals are vivid dreamers, but they show no signs of having any religion. Still, dreams in all ages have often been regarded with superstitious reverence, and were undoubtedly an element in determining the character of the primitive religion of mankind.

It has come down to us from the Latin poet Petronius that "fear first made the gods." As a complete statement of the origin of religion, it is contrary to the history and nature of man. The primary religious influence is not fear, but confidence and awe. The spirit of many early religions was quite the opposite of fear. "Probably the first of all public rites of worship," says a high authority, "was one of joyousness, to wit, the invitation to the god to be present and to partake of the repast." Many modern students of the subject would bear witness to the presence of joy and confidence in primitive religions.

Yet it can not be denied but that fear early came to be one of their most important elements. For just as with the little child, the primitive man was often disappointed in his confidence. As his experience widened and the ills of life multiplied, he began to doubt the friendly character of the spirits. He soon came to the conviction that some only were favorable to him. The rest were to be feared. And as fear once aroused feeds upon everything within its grasp and grows with extraordinary rapidity, the uncertainty as to what the attitude of the spirits would be toward him naturally caused the primitive man to spend the most of his energy in devising ways to appease their wrath.

A slight step in advance beyond spiritism was taken when the opinion began to prevail that all objects do not contain superhuman beings, but only some of them. This stage in religion is called fetishism. The term was first applied by certain early Portuguese explorers to the objects worshipped by the savage tribes they discovered in Senegal and

the region of the Congo. They found some of these peoples paying homage to such objects as a piece of wood, a feather, the fin of a fish, the claw of a bird, the hoof of a goat. Others among them regarded with reverential awe a big rock, a grove of trees, some such animal as a snail, a snake, a lizard or a crocodile. In fact, anything became an object of worship to them when they fancied that a powerful unseen being had attached himself to it.

The fact that no man ever worships a material object is well illustrated by the treatment accorded a fetish. If a fetish brings good luck, it may be sold for a high price if the owner wishes to part with it. If it brings bad luck, it is thrown away or demolished. For all virtue has gone out of it. The spirit that was in it has departed, and it has lost its power. The favorite fetish of a Papuan of New Guinea is a little wooden doll with a bright-colored rag tied around it. If a stroke of ill fortune comes to him when he has this in his belt, he will take it out and stamp on it, or tear it in pieces with his teeth, and cast it from him as utterly of no value.

As we go about over the surface of the earth, we find that different tribes have selected different objects for their fetishes, according as the objects have impressed themselves upon them as possessing superhuman powers. Among the Maoris of New Zealand spiders were paid divine honors; for it was in their gossamer threads that they fancied the souls of the departed ascended heavenwards.

Some of the Indian tribes of the northwest regarded the raven, or the thunder-bird, as they called it, as especially sacred; and according to Capt. Cook, the Sandwich Islanders also did so. The peacock, the swan, the rooster, the eagle and the dove, have been the favorite fetishes of other tribes. In Australia and Polynesia the lizard was greatly revered. The Chaldeans paid the fish divine honors. In Egypt the ox was especially sacred, and so it is in parts of India. In certain of the Fiji Islands the shark is worshipped, just as the alligator is in the Philippines. The Samoyeds in Siberia make a fetish of the whale and the polar bear.

But the most widely worshipped of all animals is the serpent. Mr. Ferguson, in his work on "Tree and Serpent Worship," finds that the serpent was accorded divine honors by nearly all the nations of antiquity, and is now worshipped in many parts of Asia, Africa and America. Among the Lithuanians in southern Russia, says a high authority "every family entertained a real serpent as a household god." Sir John Lubbock tells us that in Liberia

> No negro would intentionally injure a serpent, and any one doing so by accident would assuredly be put to death. Some English sailors once having killed one which they found in their house, were furiously attacked by the natives who killed them all and burned the house.

Closely allied to fetishism, yet indicating some advance in the evolution of religious beliefs, is ancestor-worship. This easily arises when man has developed far enough to begin to meditate upon the phenomena of death. At the very outset it is likely that death did not arouse much more interest than it does now among brutes. Britton asserts that

> The evidence is mountain-high that in the earliest and rudest period of human history the corpse inspired so little terror that it was nearly always eaten by the surviving friends.

But even this custom was probably of a religious origin. A traveler (D'Orbigny) in Bolivia tells us of an old Indian he met there whose only regret in giving up his old religion and adopting Christianity was that his body would now be devoured by worms, instead of being eaten by his relatives.

At all events, it early became an elaborate and solemn religious rite to provide the body with carefully prepared viands for its last long journey. Any neglect on the part of the survivors would be severely punished. For the soul of the departed would continue to roam about without a home, unless it was properly attended to its final resting place. Hence it became the world-wide custom among savage tribes to place in the tomb or on the funeral pyre such articles as the weapons, the clothing and ornaments of the deceased. In many cases the wives or slaves or companion-in-arms were slain or slew themselves to accompany a chieftain to his long home. Often among the American Indians they were interred in the same mound, and many such mounds exist in different parts of the country.

When a tribe had survived so long as to have a history, and to trace its descent through the male head of the family, a decided change in their religious views usually followed. As Giddings describes it:

> While the household may continue to regard natural objects and forces and miscellaneous spirits with superstitious feelings, they entertain for the soul of the departed founder of the house the strongest feeling of veneration. They think of the ancestral spirit as their protector in the land of shades. To the ancestral spirit, therefore, they pay their principal devotions.

We find it generally true that the family tomb was near the house and not far from the entrance. The children were brought up under its shadow, and constantly addressed to it their prayers. Within the house on the family altar burned the sacred fire that went out only with the extinction of the family. Around this fire all the household dead were supposed frequently to assemble to hear their mighty deeds narrated and to be reverenced and adored.

All the ancient Semitic tribes were ancestor-worshippers, and so were the Aryans when they first appeared on the shores of the Mediterranean. The Egyptians carried the cult to a high state of perfection, and the manes-worship which long held sway among the Romans is an

example of it. It is to-day the religion of the Bantu tribes of Africa, and still prevails to some extent in Japan. But it is chiefly among the Chinese that this form of religion has reached its highest form of development. All changes in the customs of the country are resisted as a reflection upon the regulations established by their ancestors, for the infraction of which they will be severely punished. The greatest sin they can commit is to allow the graves of their ancestors to be disturbed for any cause whatsoever.

As men progress in their knowledge of the things about them, they come to see the defects in the forms of religion described above, and begin to turn their attention to more exalted powers. They cease to pay exclusive homage to the spirits that reside in the objects that they themselves have handled and can make or destroy, and begin to look up in reverential awe to the beings that manifest themselves on a vaster scale, and in a more consistent and impressive manner.

Thus arose what is usually called nature-worship, the most prominent form of which is the worship of the celestial bodies. It is probable that the division of the week into seven days came about from the dedication of one day to each of the gods manifesting himself through the seven greatest luminaries.

Naturally, in all except the torrid zone, the sun-god received the greatest homage. As the source of light and warmth, as the earth's great fructifying power, as the one constant ever-recurring factor in man's daily experience, it has always awakened the most powerful religious emotions, in the minds of rude as well as semi-civilized people. Among the ancient Phœnicians the sun was the center of their cultus. It was probably the leading feature of the religion of the ancient Persians. The same was also true of the Sabeans. The worship of Apollo, so popular among the Greeks, was in all probability sun-worship. The Egyptians gave the sun a high place in their system, and the ancient Peruvians paid it their chief honors. The Celts and the Teutons, as well as the East Indians, made much of it, and so do numerous tribes in Africa to-day. It is maintained by many writers that the North American Indians were always and chiefly sun-worshippers; that the sun was actually their Manitou, or Great Spirit.

In some lands the moon was fixed upon as the chief deity. Certain Australian tribes believe to-day that all things, including man, were created by the moon.

At all periods of the world's history the stars have received special homage. Among the early natives of Greenland and Australia the Milky Way was nothing less than the pathway of souls ascending to their home in the heavens. The auroras borealis and australis were actually in their opinion the dance of the gods across the firmament.

Another form of nature worship was the adoration of the fire-god.

Among all peoples fire has been held sacred. It was thought of as the central principle of life. Among the Kafirs in South Africa every religious ceremony must be performed in front of a fire. The Indians of Guatemala regard it as their greatest and oldest deity. The fire test was practised by the Aztecs of Mexico, as well as by the Moloch worshippers of Syria. In Borneo the crackling of blazing twigs is the speech of the gods. The vestal fire of old, and the perpetual fire of the modern Christian altar are both founded upon the assumption of its sacred character.

As the experience of man widens, he discovers not only that he can destroy the tree whose spirit he worshipped, and can entrap the animals and subdue them, but also that the sun, moon and stars do not vary their action at their own option. They are obliged to move about in certain more or less prescribed courses. Even the clouds are driven to and fro by some superior power and are not free to follow their own desires. Hence he easily and naturally comes to see the truth that there must be powers above these forces that are far more worthy than they are of his homage. He rejects the notion that the forces of nature reveal the highest spirits, and he looks up to deities that can use these forces freely at their option. As distinguished from nature-worship and other lower forms of religion, this doctrine is called polytheism, although it differs from these other forms not in kind, but only in degree.

Undoubtedly, the development of this doctrine is closely related to the development of the social and governmental relations existing among the people themselves. When chiefs and kings begin to make their appearance in any community, then these greater gods begin to be recognized as over and above all lesser spirits. Oftentimes the kings and chiefs themselves are elevated to the sphere of gods, and in some cases, even while alive, receive divine honors. Rarely, however, does polytheism do away with any of the lower forms of religion. On the contrary, it usually coexists with belief in disembodied spirits, local genii of rocks and fountains and trees, household gods, and a host of other good and evil demons. The deities of this form of religion simply take their place as presiding over all inferior gods, using them as messengers or agents for the furtherance of their plans and purposes.

At first, each tribe or district is thought of as having its own particular deity. But as the tribes intermingle and learn more of one another, the tribal gods give way to national. At the outset the national gods of one country are regarded as distinct from those of another, but of equal powers. Even the ancient Hebrews considered the gods of other nations, such as those of Assyria, Phœnicia and Egypt as real divinities.

Many tribes and peoples have risen in some degree to the stage of

polytheistic thought, but the nations that carried it to a higher degree of perfection than any others were the ancient Greeks and Romans. Costly temples were erected to the honor of their gods. Elaborate ritualistic services were instituted to do them reverence. A great multitude of priests and priestesses devoted their lives to finding out and enforcing their will and purpose. The character and extent of this form of religion are, however, so familiar that there is little need of further explanation of it here.

This can hardly be said of monotheism, the next step in the evolution of religion. For there has been and in some quarters still is a great divergence of opinion regarding its historic origin. For until within a few generations, it was the common belief of thinkers on the subject of religion that the knowledge of the existence of one god was a primitive revelation, made to the first representatives of the human race, and handed down by them to their posterity. Polytheism and all other forms of religion, it was maintained, are a degeneration from a once higher form. But this view has few if any advocates among recent scholars. For it is now known that the tendency to the monotheistic position exists among all people when they have advanced to a certain degree of mental culture. As Jastrow well says:

> There is a difference in the degree in which this tendency is emphasized, but whether we turn to Babylonia, Egypt, India, China or Greece, there are distinct traces towards concentrating the varied manifestations of divine powers in a single source.

This tendency is a perfectly natural one, and arises the moment man begins seriously to reflect upon the universe. He can not fail to observe the inequalities that exist among the deities, and to realize that of necessity one must be supreme to all the others. When any two peoples united as the result of war or for any other reason, the superior place would naturally be accorded to the deity of the conquering power; and as a nation grew in influence and became conscious of its strength, it would gradually change its opinions regarding the gods of the nations about it. It would either do as the Greeks did in the case of Ammon, the god of the Egyptians, recognize in him their own Zeus as appearing in another form, or come to treat other gods as inferior deities not worthy of being compared with their own god, as the Hebrew looked upon Chemosh, the supreme god of the Moabites, in comparison with Jahveh, or Jehovah, their own national deity.

It is a matter of history that monotheism did not originate in any one quarter alone, but was an idea attained independently by many people at a comparatively early stage in their development.

The chief contribution of the Hebrews to religion is not their monotheistic idea, but the emphasis they put upon the ethical character of their supreme deity. He was not mere power that goes stalking

through the universe, but a being of righteousness that deals with men and nations according to their moral character. It was this view that caused the worship of Jehovah to supplant that of all the other gods among the Hebrews themselves, and to survive the crash of faiths that early befell the entire ancient world.

In this brief outline of the main steps that have been taken in the development of religion, it is not claimed that any hard and fast distinction can be made between them. Indeed, it is the opinion of competent authorities that all the different forms of religion described above coexisted among the Hindus, the Greeks, the old Norsemen, and to some extent still coexist among modern Africans, as well as the negroes and Indians of our own land. Nor is it held that any sudden or complete transition from a lower to a higher stage has actually taken place at any time in history. On the contrary, the changes have been gradual, and many evidences of the survival of the old amid the new exists in the notions and customs of even the most highly civilized and intelligent nations of our own day.

Amulets, charms, lucky stones and coins, the veneration of sacred relics, everything that goes under the name of "mascot," are all legitimately descended from fetishism; just as belief in ghosts and haunted houses, fear of the dark, and the like, come from a more primary form of religion. Current ideas concerning lucky and unlucky days and numbers, spilling salt, throwing rice at a wedding, charming away warts, are survivals of a similar sort. So, too, are the present notions of man as to sacred days and places, sacred utensils, holy water. And we should not hesitate to class in the list of primitive and outgrown religious ideas the worship of saints, and the common belief that a person acquires peculiar supernatural authority in religious matters by the laying on of hands, or by any other form of ordination. For they are notions on a par with the old Greek tradition that one gets a supernatural inspiration by the very act of paying a visit to the fountain of Parnassus, or taking a draft at the Pierian spring. But the most striking of all is the present popular belief that between man and the Supreme Being there exists an ascending gradation of angels and archangels on the one hand, and evil spirits on the other, reaching up to a supreme evil demon, who, under the title of Devil or Satan, is supposed to be the author of the sin and misery of mankind.

In the light of this view of the evolution of religion, we can see how irrational it is to divide religions into true and false, instead of classifying them as primitive and developed. It was maintained by Empedocles among the ancient Greeks that all religions are false because they are the product of a diseased mind, and Feuerbach in the last century strongly advocated the same view among the Germans.

While few, if any, maintain that opinion at present, there are many

who hold that all religions are false except one, and that the one they themselves have come to adopt. The Jew does this who asserts that God by a perpetual covenant, recorded in the Old Testament, has made his own race the sole repository of his will. The Islamite does this who regards the Koran alone as the sole guide to truth and life. And the Christian who sees in the New Testament the only source of religious faith and practise belongs to the same class. No writer has given us a more vivid picture of the erroneous way of regarding the religions of the World than Milton in his "Paradise Lost." That all religions except the Christian are pure inventions of the Devil to ensnare the unwary is his fundamental thought.

This position has been the source of untold mischief and suffering in the past, and immensely impedes the progress of mankind at present. It is contrary to actual fact, and is based upon the false assumption that man possesses the ability to acquire absolute certainty in religious matters, a thing which is denied to him in every other sphere.

The truth is that man's religion develops as he himself develops. The steps in the evolution of religion are the steps in his own mental advancement. There is never a time after he comes into conscious possession of his powers as a person when he is without religion, and there is no possibility of his outgrowing religion. He does not get his religion out of any book, but primarily out of the experiences of his own mind and heart. The experiences of others are a help to him only as he reproduces them in his own. The more sensual he is, the more sensual will be his religion, and the more rational and pure his life is, the more refined and spiritual will his religion become. (In other words, the more of a man he is himself, the loftier will his conception be of the Maker and Sustainer of the universe.)

THE AMERICAN PUBLIC SCHOOL

By JAMES P. MUNROE
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HORACE MANN, speaking in 1841, said: "A practical unbelief in the power of education—the power of physical, intellectual and moral training—exists among us, as a people." Two generations later are we still, as a people, unbelievers? We extol with fervor, with acclamation, with volubility, free schools; we pay our taxes not too unwillingly, spend an occasional session in our children's schools, help John and Mary, spasmodically and ineffectively, with their harder lessons, send them at some sacrifice to a high school or perhaps to college, and then thank God for the priceless blessing of a liberal education!

Having thus, with characteristic amiability and liberality done his duty according to the custom of his neighbors, the average American proceeds to exalt the "self-made" man, to deride the college and even the high school graduate, and to wonder why, with free schools and compulsory schooling, crime, folly and corruption flourish so amazingly. As in 1841, there is a "practical unbelief," not in education itself, but in the thing called education which most schools and colleges give.

We Americans pride ourselves upon being a practical people, yet fail to treat education as a practical question. Therefore, as a rule, our public schools are neither practically governed nor fitted in a practical way for the ends which they should serve. Blinded by time-honored fictions, we ignore the plainest facts. Paying vast taxes for the support of schools, we act as though the spending of that money would be guided by Divine inspiration. Making this upon education one of our largest outlays, we are content that such an enormous expenditure should be in the hands of changing and irresponsible boards, to most of whom the problems of education are as remote as the wisdom of Confucius. Setting in motion the machinery upon which we depend for the quality of future citizenship and therefore for the very existence of the republic, we are, as a rule, quite heedless whether that machinery turns out youth well fitted or totally unfit for the duties of men and women. The public schools are a business investment which stern necessity taught the founders of the nation the wisdom of making; yet the hardest thing to impress upon this nation of business men is that simple and fundamental fact.

Without public education genuine democracy is impossible; therefore the democratic state must make provision for free common schools. From every point of view, however, especially from that of the pupil's own good, those common schools should be regarded as investments from which the state, if it would prosper, must get the best possible returns. All measures in education, be they of the kindergarten or of the college, should be judged mainly from the standpoint of an enlightened political economy, from the standpoint, that is, of securing the greatest good for the greatest number by the least expenditure of social force.

Quite as much for our sakes as for theirs we require all children of certain ages to attend school and, directly or indirectly, tax ourselves to pay for this free teaching. But in paying taxes and in voting for a school board—supposing even that we do the first cheerfully and the second with some shadow of knowledge of the candidates—we are fulfilling but a small part of our duty to youth and to ourselves. There are at least two other obligations. The first of these—since we compel the child to go—is to make sure that his schooling is the best obtainable; the second—since we contribute so much to the cause of education—is to make certain that we secure the equivalent of this money in the quality of citizenship which the schools produce. If we acknowledge the wisdom of educating every child; if, not simply recognizing it, we actually compel it and set up a system against which private enterprise is powerless to compete, it would seem but plain duty to make this compulsory education humanly perfect. Even failing, however, to recognize this moral obligation, it still remains extraordinary that a nation so shrewd as ours, lavishing millions upon free education, should not look more closely to it that industrial capacity, mental and physical strength, and effective citizenship result.

Being, so to speak, a protected monopoly, the public school, to justify its favored position, should do as much for every child as any other means of education, were it free to maintain itself, could accomplish. As long as the claim can anywhere truthfully be made that parents must send their children to private schools in order to their best education, just so long the public schools are falling short of their full and essential service, a service that involves the giving, not of mere instruction, but of real education. To prepare youth for civic duty and for industrial, business or professional life, the free schools must furnish those means of intercourse, those fundamentals of a civilized society, which the casting of a ballot and the pursuit of a business or a trade demand; but, in addition and far more importantly, they must lay such foundations that every youth, broadly speaking, may become the best workman, the most successful man of affairs, the completest citizen that it is possible for him to be.

A man's real success in life is determined by two things: the degree of development of his faculties and his conduct as a member of society. It follows, therefore, that the two main ends to be sought by a public school are to give the boy command over himself and to teach him how to be a useful citizen. That is to say, public education exists in order to develop human power, and the kinds to be developed by a school are two: social power and personal power. The school must do the most it can to perfect every one of its pupils in the ability to play the largest part possible to him in the life of the community; it must help him, also, to make the most of himself. Of course these two ends of education intertwine; one can not make a boy a good citizen without making him, at the same time, a better man; neither can one make him a good man without producing, concurrently, a better citizen. To make a boy perform his due part in society he must be taught the arts of social life: how to read, write and cipher, how to comport himself, how to maintain pleasant relations with his kind. Moreover, this body of upgrowing youths must be trained and accustomed to act together, to feel their interdependence, to see the interrelations of the vast social structure perfection in which has made modern civilization possible. But, more than this, the school must, so far as it can, train, foster and direct the physical and moral forces of every individual child towards his highest individual development.

The boys who enter a counting-house or factory, the girls who take service in a shop or kitchen, the citizens who, in uncounted ways, maintain their communities and support the sovereign state, must, as a rule, know how to read, write and cipher. To do these things well counts greatly in their favor. That so many do not do them well is a serious charge against the public school. These, however, are not the fundamental qualities which employers seek and which communities require. They demand health, character, honesty, truth-telling, clean living; they demand willingness to work, readiness to comprehend, quickness of adaptation, fertility of resource, vision; they demand alertness, vigor, self-command, dexterity and muscular control. These things which result, not from set lessons, but from self-discipline, self-reliance, self-knowledge, determine the success of a boy or girl in life, and these qualities the public school must seek to develop through every means and every force at its command.

Looked at from any point of view, economic or moral, physical health is the fundamental material good of mankind. Yet what contribution does the ordinary public school make towards hygiene? As a rule it crowds fifty or sixty children into a room that, under the most favorable conditions, has fresh air enough for only thirty. It places no bar against the unwashed child, gives him no incentive or opportunity to be clean; therefore most schools contain enough of these effectually

to poison the atmosphere for those who are kept decent. All these children, breathing an insufficient quantity of more or less polluted air, are in many instances cramped into penitential desks, ten minutes' stay in which provokes intolerable restlessness, and are told by a much overworked teacher, also ill-supplied with a like bad quality of air, to keep still and to do a uniform task, a task which is too easy for some, too hard for others, and mainly distasteful to all. The teacher does her best; the pupils do better than one would suppose; both are victims of ill-planned conditions. Nothing superior to rigid discipline and unvaried tasks can be thought of when sixty little individualities, bursting with life and spirits, must be dampened into order and dragged forward somehow into that formidable next grade by an overwrought teacher whose work is judged solely by its outward results.

The inevitable outcome of such conditions, especially with growing girls and the teacher herself, is headache, nervousness, ill-temper—all the present and future ills which lurk in this Pandora's box of bad hygiene and overcrowding. Moreover, to serve as an antidote, we find in most cases nothing but some listless calisthenics, monotonous marching, and aimless romping in a bricked back-yard. So much do most schools contribute towards that foundation of a useful life, good health. Alertness, vigor, dexterity, self-command, individuality, can hardly develop out of such anti-natural conditions as these. The boy may be vigorous, alert and dexterous; but it will be in spite of the school, it will be because his life outside the schoolroom, that life which he loves, is full, as the school life is devoid, of the means to encourage those admirable and necessary qualities.

And those other virtues which the employer of young men is always seeking and so seldom finds, for which municipal life is crying out, without which the nation will perish—does one get them, as a rule, because of or in spite of the public school training? Does the setting of uniform tasks, with penalties for their neglect, either uniform or gauged by the passing temper of the teacher, develop an eagerness to work and a delight in labor? Do wholesale lessons explained by wholesale to sixty children, each one of whom has a different mind-content, a different means of apprehension, each of whom needs, therefore, special leading over every new difficulty—do these tend to promote readiness, quickness and alertness? Nothing, on the contrary, could be better calculated to dry up that intense eagerness to know, that grasping after new ideas, which most children come to school with and which, alas! so many go away without. Do desiccated text-books, rote work, graded lessons, the whole abominable system of yearly promotion, result in that quickness of adaptation, that fertility of resource, which are the very soul of civilization? Is honesty encouraged by the usual school discipline and methods? Does truth-telling always plainly get

its reward? Is purity fostered by the promiscuous herding of hundreds of children, old and young, corrupt and innocent, in the same building, under teachers whose time must be given to mint, anise and cummin rather than to these weightier matters of the Eternal Law? Says M. de Coubertin, "Not ignorance and sloth of mind threaten our younger generation so much as moral inertia and atrophy of the will. The supreme problem is to cure these." This moral inertia can be overcome, this will of the child can be developed and trained only by treating each pupil as a special problem to be worked out with knowledge, with sympathy, with tact, with enthusiasm, by every teacher under whose control the child is brought.

The bottom fallacy of much of the acknowledged inefficiency of public education is that equality implies uniformity. We are to give all youth an equal chance; therefore let us put it through one common course of study, therefore let us give it a discipline of the barracks. But this is not to secure to children an equal opportunity at all. Whose omniscience devised this uniform course which is so to act upon the antipodal natures of John and of Patrick, of Marie and of Tessa as to give them an equal chance to develop into their very best? Who found this universal solvent of all the oddities, stupidities and personalities of a townful of child nature? A uniform course is the very embodiment of inequality, making the weak weaker, the dull duller, the cross-grained more out of touch with the rest of mankind. Such a course may suit three children out of every twenty; but the remaining seventeen are mainly stupefied by it, learning only to associate what is most disagreeable, what is most useless, what is most quickly to be forgotten with those school years during which it was vainly attempted to fit their tender and growing individualities to an arbitrary mould. The only way in which to give every child an equal chance with every other is to provide for each the atmosphere and incentives suited to his particular needs and nature. Then that nature will respond and grow, revealing powers and aptitudes inconceivable under the blight of uniformity. There is no such thing as an "average child." He is a fiction as absurd as the passionless man of the old political economy. As well might one talk of an average vegetable and subject all plants to an unchanging regimen.

The fundamental principle of the "new education" which is as old as India and Greece—is to develop and strengthen individuality. All men are born free: you shall not make them slaves to a fictitious average. All men are born equal before the law: you shall not make them unequal before the law by forcing upon them a common training which gives those few whom the course happens to fit an enormous advantage, leaving the rest substantially untouched by the real forces of education. So much of the military, disciplinary side of the school as promotes

solidarity, makes children feel themselves to be social units, favors the impulse to activity arising from mere mass, is vital to the state. The marching together, singing together, playing together (provided the play be judiciously organized) is a splendid stimulus to social and civic life, impossible to be done away with. Along with this, however, and all the more strongly because of this, the individuality of the child must be nourished, promoted and developed by every rational means. Within the range of his powers all health, virtue and capacity are within him as the germ is within the seed. The teacher's business is to stimulate, to encourage and also to prune, these elemental forces. This can not be done by instruction given by wholesale, but only through genuine education acting directly upon the individual child.

Shall teachers, then, be converted into nursery governesses, one to each pupil? That extreme would be worse than the other. Under a right plan of public education, however, no teacher would have charge of more than twenty pupils; and no teacher would have charge of any at all unless, by temperament, by understanding of child nature, by a thorough professional training, he or she were fitted to make out of every one of those twenty pupils the most that can be made. Such professionally trained teachers, with classes limited to a proper size, would not simply instruct, they would really educate their pupils by giving them the tools of knowledge, not as dead processes, but as living means to illimitable ends. Out of the common, elementary studies, with no loss but with great gain in form, they would develop the content of literature, of power of expression, of sober reasoning, of world interest, of nature interest, of social and civic responsibility; and upon these fundamental studies they would lay the solid foundations of self-reliance, self-knowledge, self-respect. They would do this, moreover, not through dependence upon text-books, routine, and uniform lessons; nor, on the other hand, would they do it by excursions into psychological subtleties or by pandering to their pupils' and their own self-consciousness. They would do it as every intelligent, human man or woman who has the "faculty" of teaching and who has been taught to teach, knows how to appeal to the differing nature of each child, making him see the common fact from his special point of view and assimilate it to his personality, thereby building up by sure degrees his individual character.

Such teaching—and this is no vision; it has been demonstrated again and again—would make most children eager to go to school, impatient to learn, greedy of every new chance of mental and moral growth. Out of such an atmosphere would come a race of artisans and business men—better still, of citizens—such as the world has not yet seen. It would be a really efficient race of *working men*, neither wasting time and materials, nor shirking what they have to do; for they would

have been taught how to work, how to concentrate themselves upon a task, how to get pleasure from the mere act of doing thoroughly and well. It would be a race of studious and inventive workmen, of progressive business men and of enlightened citizens; for they would have tasted the delight which comes with the use of the acquisitive faculties, with nimbleness of wit, ingenuity of thought and adaptation of means to ends. It would be a race of self-reliant and self-respecting artisans, traders and individuals; for they would have been shown the enormous significance of the *ego,* who makes his own career and who, if he will, can make that career of tremendous importance to his day and generation.

Such a diminution in the size of classes, such an insistence upon supreme fitness in the teacher, will add incalculably to the cost of public education, through doubling the number of teachers and through doubling or trebling their pay; for present salaries will not warrant such a professional training as the new education demands. From the industrial standpoint alone, however, this added expenditure would pay vast dividends. There is frightful waste of power in the burning of coal to run a locomotive; but it is as nothing to the waste in the industrial world in the attempted utilization of human power. Ill-health, low physical force, untimely death, intemperance, vice, crime, manual inefficiency, stupidity, lack of interest, shirking—all these and many other human failings continually clog and stop the industrial machine, so that it would scarcely be an exaggeration to place the effective power of the millions engaged in gainful occupations at one tenth of what it should be. If by proper schooling this efficiency could be doubled—and it is reasonable to say that it could be much more than doubled—how infinitely would such a gain outweigh the added cost of a rational public education.

No startling changes are necessary in the free school system. Its general plan is admirably suited to American conditions. It needs but to be altered in this detail and in that, in the expansion of this principle and in the suppression of that practise. We must, however, do away with the curse of uniformity, allowing, instead, full play to individuality; we must, furthermore, fit the means and methods of the school to the real needs of the future worker and citizen; and we must, in addition, make the profession of teaching self-respecting by releasing it from its present bondage to amateurs, to well-intentioned but inexpert school boards who are jauntily settling pedagogical problems that appall trained experts. The teachers, if they are to teach from themselves instead of from prescribed text-books, must have a larger share in the control and development of schools and must be so trained and stimulated as to be fit to assume that larger share. Not elaborate buildings, or reformed courses of study, or wiser supervision will, of

themselves, make the new education succeed—it will be the teachers; and if this vast responsibility rests upon them, with them must rest also power and initiative, in them must appear professional pride far beyond what they possess to-day.

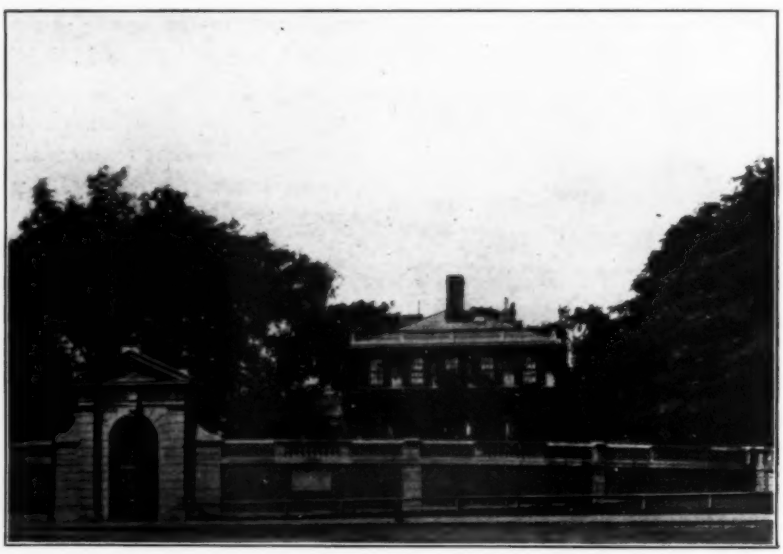
These fine, great schoolhouses, with all modern devices—provided their ventilating systems work, their floors are kept clean and their rooms are not overcrowded—are admirable; but they do not in themselves educate. The complicated apparatus, the works of art, the libraries, with which many of those schoolhouses are filled, again are admirable; but in themselves they are mere sticks and stones. The subdivision of labor among teachers, the calling in of specialists, the elaboration of methods of teaching are—sometimes—excellent; but they are but the husks of real education. Psychological laboratories, child-study, the heaping up of great masses of pedagogical data are also, when backed by real knowledge, excellent; but they are only minor helps to a real education. Pile buildings, apparatus, methods, psychological subtleties high as Pelion on Ossa and there will result no better education than was given in the ancient district school unless behind this complexity of educational machinery are real teachers knowing how to teach and with time to do true, individual teaching. The more we elaborate education, the more time we spend on pedagogical minutiæ, the more we load ourselves down with apparatus, the more plainly it appears that the sole essential for real education is the educated teacher who knows how to teach. Upon his, or her, personal fitness rests the future of the country; with him, or with her, not in systems and apparatus, lies the solution of this vexed question of the public school. The regeneration of mankind will be brought about, so far as the common school can effect it, by the direct, human influence of the individual teacher upon the individual pupil.

Such teachers, however, will not appear in numbers sufficient to make their influence felt until they are assured of decent remuneration, of tenure of office during real efficiency, of small classes, and of a professional standing regulated, as is that of physicians and lawyers, by the profession itself. And only when the great public gives that assurance, by its individual and corporate support of those who are trying to foster the new education, will it prove that it really believes now, any more than it did in 1841, in the actual "power of physical, intellectual and moral training."

THE PROGRESS OF SCIENCE

HARVARD UNIVERSITY AND THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BOSTON is still the chief educational center of the country. Among its institutions for higher education, Harvard is our greatest university and the Massachusetts Institute of Technology our greatest school of technology. This year Harvard is for the first time surpassed by Columbia in the number of students, and it will soon be overtaken by several of the state universities. Cornell and Michigan have more students in applied science than the Massachusetts Institute of Technology. But Harvard and the institute have been leaders in setting certain educational ideals, and each will for a long time maintain its preeminence. Harvard consists of a college with free electives for culture and professional schools based on it; whereas the institute aims to give culture with and through its professional studies. The outcome appears to be more play at Harvard and more work at the institute. It is extremely difficult to appraise the value of an educational system by its results on the students. So long as students of the upper classes with their hereditary and social advantages or students selected from all classes by their superior ability and enterprise go to college, and so long as the college is the natural gateway to certain careers, it is not possible to test the value of a college education by its objective results on the future success of the students. When, however, the graduate school of applied science endowed with the income of the McKay bequest at Harvard has been completely established, it may be possible to make an interesting comparison of its work with that of the institute.



THE PRESIDENT'S HOUSE, HARVARD UNIVERSITY.

PROFESSOR A. LAWRENCE LOWELL,
President-elect of Harvard University.

It is a curious fact that the two institutions, after the unsuccessful attempts to form a merger two years ago, should now at the same time elect new presidents. In the men selected and even in the methods of selection, the institutions have shown their individuality. Harvard has in the most gentlemanly manner elected a member of its own set; the institute after floundering about has chosen a man from the antipodes.

Professor A. Lawrence Lowell, elected to succeed Mr. Eliot as president of Harvard University, belongs to the Harvard and New England aristocracy. The cities of Lowell and Lawrence were named from his ancestors, who for generations have maintained traditions of wealth and culture. Of this stock he is typical, even to the extent of having married his cousin and having no children. In an address made very shortly before the election of his successor, President Eliot said: "When the corporation selects some young man to take my place I hope you will all look at him with this one inquiry—is this a promising young man, is he a young man who has in him a large capacity to grow?" But the corporation chose a man completely formed by heredity and experience, eminent as an author of important books on government, trained first as a lawyer in charge of large vested interests and later as a professor, lecturing in courses attractive to college students. We may be sure that Mr. Lowell will be as exemplary as president of Harvard as in every other relation of life, and that the traditions and spirit of the university will be safe in his hands.

Professor Richard C. MacLaurin, president-elect of the Massachusetts Institute of Technology, though born in Scotland and completing his university studies in Cambridge, has spent most of his life in New Zealand, where he was professor of mathematics in Wellington. A little over a year ago, he accepted the chair of mathematical physics in Columbia University, which had been vacant since the election of Professor R. S. Woodward to the presidency of the Carnegie Institution. Professor MacLaurin has recently pub-

PROFESSOR RICHARD C. MACLAURIN,
President-elect of the Massachusetts Institute of Technology.

lished the first volume of an important work on mathematical optics. He has also been trained as a lawyer and has broad interests in philosophy and education.

It is a fact of some interest that Mr. Lowell is a member of the corporation of the institute and with Dr. Pritchett represented the institute in the joint committee of the corporations which recommended the merger with Harvard. The most important action of Harvard since the election of Mr. Lowell has been the calling of two heads of departments of the institute, Professor Swain and Professor Clifford, to its Graduate School of Applied Sciences.

ENGLISH VITAL STATISTICS

THE recently published report of the English registrar general shows that the death rate of England and Wales during 1907 reached the remarkably low figure of 15 per thousand of the population. This is 2.4 per thousand lower than it was ten years ago; it is lower than for any other nation, except perhaps Sweden and Norway, though the lowest recorded death rates appear to be in Indiana and Michigan, where in 1905 they were 12.8 and 13.5, respectively. There is nothing more appalling than, and at the same time so hopeful as, the great differences in the death rates in different parts of the civilized world. It seems almost incredible that in one country or in one city twice as many people of each thousand inhabitants die as in others. We may sympathize with Tolstoy in his grief for the cruel executions that occur in Russia, but they are after all an insignificant matter compared with the fifty million people who have died needlessly in that country in the course of the past twenty-five years. But we need not go to Russia for a warning, when the death rate in New York is twenty per cent. higher than in London, when ten times as many in proportion to the population die from typhoid fever in Pittsburg as in New York, or when the death rate in one Massachusetts town is twice as high as in another.

It is gratifying that the infant mortality in England in 1907 was as low as 118 per 1,000 births, as compared with an average of 145 in the ten preceding years. But it is an ominous fact that the birth rate has fallen even more rapidly than the death rate. The birth rate in 1907 in England and Wales was 26.3, as much as 0.8 lower than in the preceding year and 10 lower than in 1876. If this fall should continue there would be no children born in England at the close of the present century. Absurd as this may appear, it is difficult to see why if the average family has decreased from four to three in the course of thirty years, it may not continue to decrease to two and to one.

On the other hand, the death rate can not continue to decrease indefinitely, and indeed it seems to have almost reached its minimum. When one thinks of the vast amount of intemperance, poverty and preventable disease in England, it might appear that there is room for endless improvement. But even a death rate of 15 is paradoxical. This means that only one person in 66.6 dies each year, and if the population were stationary the average duration of life would be 66.6 years. As one infant in seven dies, the average age at death of those who survive the first year would be 77, which obviously it is not, nor is likely to be. The paradox is explained by another paradox, namely, that a high birth rate tends to give a low death rate. Countries, cities and classes having a high birth rate usually have a high death rate and the infant death rate is nearly ten times the average; yet it is the high birth rate in England in past years which gives it its present low death rate.

If the birth rate of a country should

M. Gabriel Lippman,
The eminent physicist of the Sorbonne, to whom the Nobel prize in physics has been awarded.

suddenly increase, its death rate would also increase at first, owing to the high infant mortality, but in the subsequent fifty years the population would be composed largely of people between the ages of ten and fifty years, whose death rate is the smallest, and the death rate of the whole country would be low. Thus in England the greatly increased population of the country is due to the high birth rate in the sixties, seventies, eighties and nineties. Although the recorded birth rate was higher in 1876 than previously, this is probably due only to the improved registration. But the ever increasing population has given a composition such that those predominate in numbers who are at ages at which the death rate is low. Of a thousand people in France, about 125 are over sixty years of age, of a thousand in England only about 75 are of this age. The lower death rate in England is largely due to its more youthful population. It may decrease somewhat further, owing to improved hygiene and sanitation; but if the birth rate continues to decrease there will come a time when the death rate will increase.

ALBERT GAUDRY

In the loss of Professor Gaudry, who died recently in Paris, paleontology suffers not only in France but in the world at large, for he was an investigator of rare ability who was also gifted with a felicitous mode of expression. It is remarkable that his earliest work of note was also his greatest. This was the memoir on the fossil mammals of Pikermi, a small hillock of Upper Miocene age in Greece. Taken altogether, the volume on the Pikermi mammals is the finest contribution which has ever been made to the paleontology of the mammals in Europe, with the possible exception of Kowalevsky's great memoirs of 1873. Similar works appeared on fauna of the same age at Mt. Leberon. Gaudry's most popular volume was his "Enchainements du Monde Animal."

The most original feature of Gaudry's research on the Pikermi fauna was his recognition of the polyphyletic nature of the evolution of the horses, rhinoceroses and other animals whose remains are found in such profusion in this classic locality of Greece. Gaudry's other great service to science was the building up of the splendid collection in the Jardin des Plantes, Paris, and the artistic finishing of the famous "Gallerie de Palæontologie," which contains the older collections which have found their way to Paris, including the classic types of Cuvier and de Blainville.

Professor Gaudry was a man of charming character and personality, a French gentleman of the old school; extremely sympathetic in his relations with others, and cordially enthusiastic in recognition of their work. He always showed marked hospitality in his reception of visiting paleontologists to the Paris museum, and was warmly welcomed on his rare journeys to foreign countries.

SCIENTIFIC ITEMS

The Astronomical Society of the Pacific has awarded its Bruce gold medal for the year 1909 to Dr. G. W. Hill for distinguished services to astronomy.—The first award of the gold medal recently established by the Smithsonian Institution in memory of the late Secretary Langley has been made to Messrs. Wilbur and Orville Wright.—M. Henri Poincaré, the eminent mathematician and philosopher, has been received into the French Academy, taking the seat vacant by the death of the poet Sully Prudhomme.

Dr. S. Weir Mitchell celebrated his eightieth birthday on February 15, and Professor Ernst Haeckel his seventy-fifth birthday on February 16.